The development of a methodology for the evaluation of installed CAPM system's effectiveness and efficiency

Sitoh, Paul Jek

THE DEVELOPMENT OF A METHODOLOGY FOR THE EVALUATION OF INSTALLED CAPM SYSTEM'S EFFECTIVENESS AND EFFICIENCY

Paul Jek Sitoh

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VOLUME I

ABSTRACT

The objective of this work was to design, develop and evaluate an audit for a Computer Aided Production Management (CAPM) system. Such systems, despite their costs of purchase and implementation, find wide application in industry but there is still considerable debate as to their contribution to the overall performance of a company.

A variety of possible methodologies were explored. However, it was found that most of the existing analytical techniques tended to focus on a comparison of systems with respect to best practice or to require data that a company was unlikely to have. Best practice is not an absolute measure, nor does it take account of different company types and their individual requirements. A flexible methodology, 'the CAPM Audit', designed to establish the effectiveness and efficiency of any installed CAPM system, has been developed. The audit is a development of the Delphi approach and is designed to establish the contribution of the CAPM system to the company's overall competitive position. In its development, a generic model for any CAPM system was devised to facilitate analysis without reference to any particular technology, management mode, or manufacturing control system.

The audit developed (in the form of a workbook) consists of four stages: stage one establishes the context; stage two determines the underlying architecture of the system; stage three quantifies the contribution to the company's competitive position; and stage four identifies the causes of any failure of the CAPM system. The design of the audit is such that: it enables a systematic investigation of the effectiveness and efficiency of an installed CAPM system to be completed; it enables the CAPM system's contribution to the company to be identified; and it also enables any inadequacies to be determined.

ABBREVIATIONS

AAA	American Accounting Association
CAD	Computer Aided Design
CAPM	Computer Aided Production Management
CIM	Computer Integrated Manufacture
CRP	Capacity Requirements Planning
DBMS	Data Base Management System
DSS	Decision Support System
EDI	Electronic Data Interchange
EOQ	Economic Order Quantity
GT	Group Technology
ICA	Institute of Chartered Accountants
ISO	International Standards Organisation
IT	Information Technology
JIT	Just-In-Time
MIS	Management Information System
MRP	Material Requirements Planning
MRP II	Manufacturing Resource Planning
OPOC	Order Point Order Control
OPT	Optimised Production Technology
RCCP	Rough Cut Capacity Planning
SADT	Structured Analysis and Design Technique
SSADM	Structured System and Design Methodology
TPS	Transaction Processing System

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DECLARATION

This thesis describes the work involved in the development of an audit methodology for the evaluation of installed CAPM system effectiveness and efficiency. Unless otherwise acknowledged, the work described in this thesis remains the sole responsibility of author.

1. INTRODUCTION

1.1 Background to the Project

Computers are widely seen as panaceas for many of the problems of manufacturing. The introduction of Computer Aided Production Management (CAPM) systems is regularly accompanied by promises of improved sales performance, reduction of lead-time, improved machine utilisation, etc. Unfortunately, such predictions are rarely achieved in practice. A consultant firm, A.T. Kearney[1], presented findings indicating 'successful' Information Technology (IT) users having a return on capital employed of 22.9%, which is only marginally better than the 19.6% for 'unsuccessful' ones. Despite this, Feeny et al[2] noted a tendency to dismiss as a major issue the provision of quality information at an acceptable cost. The impetus has been towards the introduction of new technologies and often, as Marchi[3] noted, these are not underpinned by a careful analysis of the installed system.

The lack of analysis of installed IT is not helped by the complexity of the task. As technologies advance, the role of IT may change. For example, the latest developments such as multimedia, hand-held computers and networking technologies have the potential to change communications between computers. In turn, new effectiveness and efficiency criteria may be required. The problem with many evaluation methodologies is that they lag technological development and, if applied, could have the effect of reinforcing obsolete effectiveness and efficiency criteria.

The lack of emphasis on evaluating installed IT does not imply a lack of evaluation methodology. Seward[4] noted that although many methodologies have been developed, the emphasis is often on operational efficiency (i.e. doing things correctly) rather than system effectiveness (i.e. doing the right thing).

1.2 Mission Statement

The project's mission is to develop *audit* interview and survey techniques for the evaluation of installed CAPM system effectiveness and efficiency. For want of a term, such techniques shall be called the CAPM audit.

The choice of the term audit, is meant to denote underlying synergy between the principles of auditing and the evaluation of CAPM systems. In order to fully appreciate the project mission, it is useful to review the principles of auditing and the types of audit.

1.2.1 The principles of auditing

According to the Institute of Chartered Accountants (ICA)[5] of England and Wales, an audit is defined as:

> *"...the independent examination of, and expression of opinion on, the financial statements of an enterprise by an appointed auditor in pursuance of that appointment and in compliance with any relevant statutory obligation."*

The American Accounting Association (AAA) Committee on Basic Auditing Concepts, which states that:

> *"...auditing is a systematic process of objectively obtaining and evaluating evidence regarding assertions about economic actions and events to ascertain the degree of correspondence between those assertions and established criteria and communicating the results to interested users."*

The Institute of Internal Auditors (IIA)[6] defines internal auditing as:

> *"an independent appraisal activity within an organisation for the review of operations as a service to management. It is a managerial control which functions by measuring and evaluating the effectiveness of other controls."*

Definitional semantics notwithstanding; an audit, as Howard[7] indicated, is fundamentally an *investigation* followed by some *conclusion* about some problem domain. As in any investigatory work, auditing requires a combination of knowledge and experience. It is also not unexpected that auditing involves an incremental and iterative process. Thus, auditing does not necessarily lend itself to cook-book methodology.

On the other hand, auditing is also constrained by the need for objectivity. Meaning, the auditor must present his or her audit inference undistorted by emotional bias. Clearly then, some element of discipline is necessary. Discipline here implies a repeatable or traceable audit process, an audit process that is properly focused and an audit inference based principally on facts.

With regards to this project, the tasks of audit development are:

a) Defining and/or identifying a system of methods and principles, such that discipline is injected in the audit process but not to constrain scope for innovation.

b) The creation of a structured framework in support of the audit process.

1.2.2 Types of audit

An audit can be either statutory or private. Statutory audit implies applications within the context of either legal statutes, such as the Companies Acts; or statutes of professional bodies, such as the British Standard Institute's BS 5750. Private audits or internal audits, on the other hand, are undertaken at the request of the interested parties. A private audit is, first and foremost, a service to a client and as such the client has the right to define the scope in which internal audit is to be applied. The client may decide on either a complete or partial audit.

The issue of a complete or partial audit relates to the auditor's independence. There are numerous parameters of independence but, generally speaking, independence is about access to data. In a complete audit, the auditor is given total independence to the extent that he or she is mandated to investigate in any way seen fit. Partial audits, it follows, are scenarios where an auditor is not given total independence.

1.3 Project Objectives

The objective of this project is to identify and develop a methodology in accordance with these broad requirements:

a) The CAPM audit is intended as an investigation of installed CAPM systems. Paraphrasing the definition offered by Burbidge[8], CAPM systems are infrastructures utilising digital computer technology to aid the planning, direction and control of the material supply and processing activities of an enterprise in such a manner that the labour, plant and capital are used to advantage.

b) The CAPM audit must be applicable to CAPM systems used in all forms of discrete manufacturing. By the phrase 'in all forms', is meant manufacturing in both large scale and small scale, and any industry type.

c) The CAPM audit must be applicable to CAPM systems of any architecture. This implies systems being investigated need not be fully computerised. It also means the audit is not only applicable to a specific management paradigm, such as Materials Requirement Planning (MRP), Just-In-Time (JIT) or Optimised Production Technology (OPT).

d) The CAPM audit is to be a private audit and applicable over a varying degree of completeness (i.e. ranging from partial to complete).

1.4 Thesis Outline

This thesis consists of two volumes.

Volume I of the thesis discussed the issues involved in the development of the CAPM audit. The development of the audit is characterised by three key phases: Analysis, Design and Evaluation.

a) In the analysis phase, issues on the problems of auditing (Chapter 2), scope of a CAPM system (Chapter 3) and, effectiveness and efficiency criteria (Chapter 4) are addressed.

b) During the design phase, issues relating to the justification for a new audit (Chapter 5) and structuring of the CAPM audit (Chapter 6) are addressed.

c) Finally, the evaluation phase deals with the application of the CAPM audit in trial scenarios. The result of the evaluation is discussed in Chapter 7.

Volume II is a working version of the CAPM audit workbook.

2. THE PROBLEM OF AUDITING

2.1 Chapter Introduction

This chapter describes the problems of auditing from two perspectives: methodological view and auditor's independence. From a methodological perspective, the issues discussed focus on the principles of auditing. From the auditor's independence perspective, issues discussed focus on the pragmatics of auditing.

2.2 Problems from a Methodological Perspective

Carlson[9] introduced the concept of "impact evaluation" as the basis for the evaluation of information systems. Impact evaluation is a process of establishing the relationship between an initiating system (i.e. source of impact) and a target system (i.e. where impact is directed).

In the context of a CAPM audit, the question of system boundaries must seem obvious. The "initiating system" ought to correspond to the CAPM system whereas the "target system" is the manufacturing system. Beyond this generalisation, however, the exact system boundaries are far from obvious. In particular, are CAPM users parts of the initiating system or target system?

Carlson[9] further points out that the choice of boundaries is essentially a matter of conjecture. The choice of boundaries, however, does have implications for the validity of any inferences from impact evaluation.

To appreciate the implications on validity, it is necessary to note, as the American Psychological Association[10]] indicated, that there are three types of validity. These validities are termed 'Content validity', 'Criterion-related validity' and 'Construct validity'.

2.2.1 Content validity

Bohrnstedt[11] describe content validity as:

> ".. *the degree that one has representatively sampled from that domain of meaning.* "

Simply put, content validity refers to the number of criteria needed to benchmark the effectiveness and efficiency of a CAPM system. Unfortunately, there is no single criterion by which a CAPM system can be judged. To a majority of general managers' cost reduction is deemed the main benefit of computerisation(see Production[12]). In another survey by Farhood et al[13] on operational managers' attitude, reduction in cost was considered a less important benefit than flexibility and quality. Finally in a survey by Kenny and Dunk[14] of production planners, the results suggested that criteria relating to variance between planned and actual events took precedence over cost and flexibility consideration.

Despite these myriad views, there are fundamentally two basic views of effectiveness and efficiency. Hamilton and Chervany[15] described these views as either 'system-resource' or 'goal-centred' criteria. System-resource criteria relate to the extent of divergence from 'good practice' norm. For instance, in MRP-type CAPM systems, a good practice criterion is the accuracy of BOM. On the other hand, goal-centred criterion relate to how well system meets functional criteria. Since CAPM system is concerned with level of inventories, a useful functional criterion is inventory turnover.

In theory both types of views ought to lead to the same conclusion but this is not necessarily the case. For instance, from the goal-centred view inventory turnover may be useful in indicating how well a company manages its inventory. However, the criterion does not always directly link to the source of performance. A poor inventory-turn over performance could be equally attributed to lot sizing or even inaccurate BOM. Hence accurate BOM does not necessarily lead to good inventory-turn over. In practice, therefore, both goal-centred and system-resources views are needed:

a) The goal-centred views are needed to quantify the impact of a source.

b) The system-resource views are needed to identify the source of impact.

2.2.2 Criterion-related validity

For current discussion, it is useful to note the distinction between a 'criterion' and a 'measure'. A criterion refers to a phenomenon to be validated. In the context of the CAPM audit, the criteria of interest relate to the effectiveness and efficiency of CAPM systems. A measure, on the other hand, refers to a piece of information (e.g. a number) assigned to a criterion. The information assigned represents the state of quantity of a phenomenon. Empirical validity is the extent of correlation between a criterion and a measure.

There are instances where a criterion and a measure may not correlate. By way of illustration, consider the following examples highlighted by Plossl[16].

a) *Direct labour efficiency.* This criterion is intended as an indicator of the extent of *useful* output from a labour unit. This criterion could be calculated from measures of labour output. However, if the measures used is derived from non-bottleneck labour unit, there can be problem. This is because any measures that reflect high efficiency in bottleneck resource is actually a reflect of over production, not necessarily useful outputs.

b) *Reduction of direct material cost.* A comprehensive measure of material cost should include cost of ordering, follow-up cost and carrying cost. However, it is not uncommon to find companies using only purchase price as a measure of cost. The result is a partial reflection of material cost.

c) *Recovery of investment on machine.* Book values are often used to calculate this criterion. Unfortunately, book values have the effect of showing a poor return on investment in new machines; thereby obscuring the recoveries derived from the benefits of flexibility offered by new machines.

d) *Reduction in the complexity of work (e.g. production of report) due to computerisation.* A precise measures for this criterion is very difficult if not impossible to obtain. Often the amount of paperwork is used (see Holden and Hall[17]) for such calculation. However, there is no clear correlation between paperwork and the nature of work. Computerisation merely changes the nature of work from paper to an electronic medium; the inherent complexity of work is not changed.

2.2.3 Construct validity

A CAPM audit has to provide more than statements of CAPM system effectiveness and efficiency; it is necessary also to explain why systems fail. Construct validity is concerned with the degree of validity in the audit conclusion. Finding valid explanations for CAPM system failure is not straight-forward. From many research in these areas, numerous explanations maybe found. In broad terms, there are two schools of thought on the matter of CAPM failure.

One school of thought is that the failures are attributable to the way CAPM systems are used rather than the enabling technology (i.e. software and hardware). Orlicky[18], for example, noted that CAPM failures are due to the lack of top management support, poorly educated system users, unrealistic master production schedules and inaccurate Bills of Material (BOM). Other researchers, such as Monniot et al[19], have also come to the same conclusion.

The other school of thought is represented by the research findings of Hendry and Kingsman[20], Hoey et al[21], and Aggarwal and Aggarwal[22]. The theme behind this school is that the failure of CAPM systems is attributable to the immaturity of the enabling technology. The following illustrates two classic conclusions:

a) JIT-type systems are applicable only to repetitive manufacture.

b) MRP-type systems require *a priori* fixed lead-time estimates, which are often not readily available.

In considering these two views, one is drawn to the question: which school of thought is the correct one?

It would appear that neither technological- nor infrastructure-based explanations on their own present a complete explanation. Take for instance, inaccurate BOM. True, inaccurate BOM can lead to poor estimation of schedules. But then what was the cause of accuracy in the first place?

Poor BOM accuracy could have been attributed to a lack of discipline. However, it could just as well be that MRP was applied in context where accurate data was genuinely difficult to obtain, such as situations where customised items are manufactured. In those situations, advance knowledge of lead-times is not readily available. It is, therefore, inaccurate to attribute failure simply to the failing of the MRP methodology.

The only way in which one is able to provide a correct explanation is to deal with the problem holistically. A point clearly noted by Rhodes[23], who wrote:

> *"Many enlightened companies of any kind know that the elements of successful production management are: to understand the overall subject; to be able relate it to their business; to contain a desire to innovate until benefits are perceived; and to apply only what is relevant."*

2.3 Problems Relating to Auditor's Independence

If auditing were meant to detect frauds, then there is no question of the need for independence. In the context of a CAPM audit, however, what rationale is there for independence?

Independence, in the context of CAPM audit, is simply a means to an objective outcome. Logically, by ensuring that auditors are adequately detached from the problem domain, an objective outcome can be assured. In reality, as Chambers and Court[24] noted, complete independence is never a real option for these reasons.

a) It is misplaced to assume that the client will ever agree to unbridled access to data in the interest of objectivity. Apart from security reasons, unrestricted access could impede the operations of company.

b) The fact that a CAPM audit is a private audit implies that it is a service to the client. Thus, any audit inference itself is not an end but a basis for further action. Even at the risk of compromising independence, it is clearly useful for the client be engaged in the audit process.

c) A definite way of ensuring independence is to delegate the audit tasks entirely to an outside agency. This approach can potentially be seen as a threat.

d) Complete independence, without appropriate focus can lead to overemphasis on trivial issues.

On the other hand, the lack of independence such as engaging the user of CAPM system to perform the audit has the danger of a less than objective result. Not surprisingly, having invested heavily in a particular system, CAPM users may be tempted to justify what they have got even if it is illogical to do so.

Inevitably a balance must be struck between the desire for complete independence and pragmatism.

2.4 Chapter Summary

This chapter raised two questions for this project and they are:

a) How to develop a methodology that will be valid?

b) How to strike a balance between the desire for independence and pragmatics?

On the issue of methodological validity; this project has decided to approach the issue of effectiveness and efficiency of a CAPM system in terms of system depends not on the kind of CAPM system used but how well the company satisfies its overall business mission. Clearly, a CAPM system should not be judged in any lesser way.

On the issue of auditor's independence, this chapter has also noted that the CAPM audit can gain from client-auditor interactions. To that end, the CAPM audit will be best served by a framework that will support any such relationship, whilst maintaining a rational approach which will reveal any shortcomings.

3. DEFINING THE SCOPE OF CAPM SYSTEMS

3.1 Chapter Introduction

Knowledge about a CAPM system depends significantly on the way the system scope is defined. If the scope of a CAPM system is defined purely in technological terms, the non-technological factors are excluded. In auditing terms, problems attributable to non-technological factors could be overlooked. Also, if the scope of a CAPM system is defined to a particular *modus operandi*, such as MRP or JIT, there is a potential of inculcating a fixed mindset and, thus, a danger of encouraging obsolesces.

One of the requirement of the CAPM audit is to provide a framework to analyse an installed system as is currently instituted not what the system ought to be. To fulfil this requirement, a generic CAPM framework was formulated. The generic framework shall function as a base-line reference for any CAPM system *modus operandi* and technological architecture.

The purpose of this chapter is to discuss the thoughts and knowledge involved in the formulation of the generic Framework.

3.2 Fundamental Management Models

A CAPM system could be viewed from the perspective of operational research. This perspective suggeststhat a CAPM system is composed of software modules applying linear programming techniques, inventory modelling and scheduling techniques for planning and control. While a CAPM system may use some operational research technique, such as Economic Order Quantity (EOQ), but it is too simplistic to assume that a complete CAPM system is simply a straight-forward application of operational research techniques. In reality, operational research techniques are more likely to support decision making rather than a decision making mechanism itself (see Alter[25]). As Gershwin et al[26] noted, the overwhelming volume of data and the wide variations in planning horizons in any production management system are likely to present significant computational difficulty for automated decision making based purely on operational research techniques.

A CAPM system can also be viewed as a closed loop control system organised in a functional and hierarchical framework. Hierarchy provides a mechanism where higher level decisions impose constraints on lower levels as in the case of the relationship between Master Production Scheduling (MPS) and MRP. The functional framework provides a mechanism to organise decision making according to specialisms such as scheduling, inventory management or capacity management. Unfortunately in an increasingly competitive environment, the hierarchical and functional framework is demonstrating its fallibility. A problem with this model is that it offers a sub-optimal solution. The MRP/MRP II type CAPM system is based on this model. As Flapper et al[27] noted that MRP/MRP II merely accepts the current values of manufacturing variables and then generates plans that are appropriate for the variables. That means, MRP/MRP II does not address the validity of manufacturing variables *per se*. JIT, as Browne et al[28] noted;

> *"involves the design of the manufacturing system in its broadest sense, addressing the issues of marketing, sales, product design, process engineering, quality engineering, plant layout and production management in order to facilitate JIT production using the Kanban system."*

Using the Mintzberg's[29] model of management system, one could view a CAPM system as a combination of five basic control mechanisms:

a) *Mutual adjustment* where control is achieved by informal communications. The so-called Kanban system of JIT is an example.

b) *Direct supervision* where control is achieved by one person giving orders to others.

c) *Standardisation of work processes* where control is achieved through the specification of work content. This technique is found in JIT's emphasis on product design that will minimise problems caused by unnecessary non-value added activities (see Boothroyd and Dehurst[30]).

d) *Standardisation of output* where control is achieved through the specification of results to be achieved.

e) *Standardisation of skills* where control is achieved through an indirect approach as in the case of flexible labour in a JIT-type system.

The Mintzberg's[29] model is a useful mechanism for appreciation of the concept of both formal and informal control mechanisms. However, it lacks the framework to explain the roles of computer systems.

A CAPM system could also be viewed as a kind of Management Information System (MIS). According to Davis and Olson[31];

> *"An MIS is an integrated, user-machine system for providing information to support operations, management, and decision-making functions in an organisation. The system utilises computer hardware and software; manual procedures; models for analysis, planning, control and decision making; and a database."*

In terms of modules, an MIS will consists of a Decision Support System (DSS), Database, Transaction Processing System (TPS) and Users; all of which relates in the manner shown in Figure 1. The advantage of the MIS framework is that it will provide a way of appreciating enabling technologies and their interrelationship. However, this model does not offer explanations of how enabling technologies are used.

3.3 Reviewing Conventional CAPM Systems

The previous section presented a number of models as ways of viewing CAPM systems and noted that each model, individually, was inadequate. However, combining the models could offer a much more holistic view of CAPM systems.

The problem was establishing a combined model and for want of a term, the model is to be referred to as a 'Generic CAPM framework'

To construct the Generic CAPM framework, conventional CAPM systems, namely MRP II, JIT and OPT, were analysed. The objective of the analysis was to uncover elements that were common to all of the conventional systems.

3.3.1 CAPM from an MRP II perspective

MRP II is actually combination of concepts. Firstly, it is a type of planning and control paradigm. Secondly, it is a technology designed to facilitate computation of requirements plans.

As a planning and control paradigm, MRP II production management operates in a functional and hierarchical close loop framework. A detailed description of MRP II can be found in texts by Smith[32], Wild[33] and Vollmann[34]. Broadly speaking, MRP II is organised as modules of Master Production Scheduling (MPS)[@], Rough Cut Capacity Planning (RCCP), Materials Requirement Planning (MRP), Capacity Requirements Planning (CRP) and Shop floor control. These modules operates in this manner:

a) MPS is concerned with the scheduling of end-items and/or final assembly. There are various approaches to MPS. One possible approach is to simply forward and backward schedule against cumulative lead-time. Another approach is to schedule against finite capacity from the inputs of RCCP. For details further details of RCCP, refer to articles by Anderson and Ostrenga[35].

b) MRP is concerned with the scheduling of sub-assembly and component items. The inputs (i.e. end-items schedule) for MRP are derived from the output of MPS. Hence a hierarchical framework. The typical approach for MRP scheduling is to identify the assembly and component items against a BOM, each item is then backward scheduled against planned cumulative lead-time and/or lead-time calculated from the inputs from CRP, although other scheduling strategies can just as well apply.

c) The shop floor control module is concerned with execution of decisions established at the MRP level. The module will also monitor stages of execution and feed-back to information to the higher level modules, in order to flag any exceptions, such as failure to meet planned schedules.

Any MRP II-type implementation will have a core computational technique known as MRP. In technological terms, an MRP is primarily a tool for the calculations of net inventory requirements against a defined BOM. MRP II also uses other types of computational techniques. A typical range of computational techniques found in any MRP II-type implementation might include Economic Order Quantity (EOQ), Lot-for-Lot and Period Order Quantity (POQ) batching rules. Others might include a range of forecasting techniques such as running

[@] It is useful to note that the term MPS refers to a type of master scheduling peculiar to MRP/MRP II environment whereas the term master scheduling refers to the scheduling of end-items and final assembly in any environment.

averages or simple linear regression. For other examples, refer to an overview of some MRP II implementations by Braiden[36]. The point to note is that from a technological perspective, MRP II is simply a DSS.

3.3.2 CAPM from the perspective of JIT

A key element in any JIT-based system is the Kanban system. The Kanban system actually encompasses two underlying concepts. In one respect, Kanban corresponds to a particular kind of operational scheduling policy based on mutual adjustment. The other aspect of Kanban corresponds to a form of scheduling strategy in that work schedules depends entirely on the pace set by the worker. In the case of MRP/MRP II systems, work schedules are dictated by planned due dates.

The JIT approach has implications for process planning in that some kind of Group Technology (GT) type policy is necessary, if the Kanban approach is to succeed. GT corresponds to Mintzberg's[29] concept of 'standardisation of work processes' as a control procedure. Therefore, a holistic appreciation of CAPM systems should also account for this form of control framework.

JIT also contrast with MRP II-type CAPM systems in terms of supplier sourcing policy. In the case of JIT the approach is based on long term relationships. Through long term relationships, supply scheduling policy can also be achieved by Kanban or pull scheduling (see Hampton and Cook[37]). The MRP II approach is based on the concept of multiple-sourcing and planned due dates.

Kanban also corresponds to a TPS in that it facilitates the monitoring and execution of work without having to generate transaction records for each and every work stage. A Kanban can be as simple as coloured balls to enact transactions (i.e. movement between resources). In the case of the MRP/MRP II approach, its TPS is used to translate information from a requirements plan into job cards, which contain details outlining each and every work stage. The cards are then transmitted to the job concerned and signed off at the end of each stage.

The enabling technologies for a JIT-type system need not necessarily be dissimilar to those used in MRP/MRP II-type systems. For instance, in JIT, the approach to schedule end-items (i.e. master schedule) is on the basis of a technique known as production smoothing and mixed model production. For a detail discussion of this technique refer to the explanation offered by Moden[38]. Broadly speaking, the technique involves spreading a lot size in equal demands over a planning horizon thus smoothing out the production. The mixed model concept involves production of mixed batches of products. The calculations necessary for production smoothing and mixed model batch sizing could be achieved by altering the MRP/MRP II algorithm to mimic the effect of production smoothing. This means using the algorithm in MPS and RCCP in an iterative fashion:

a) Step 1 - set out a mixed model schedule on the MPS;

b) Step 2 - use the RCCP module to calculate the capacity necessary to meet the master schedules;

c) Step 3 - repeat Step 1 until a smooth loading is achieved (i.e. no discrepancy between MPS and RCCP).

A much more elegant approach is to incorporate a dedicated production smoothing algorithm into the MPS and RCCP modules directly.

3.3.3 CAPM from the perspective of OPT

The aim of an OPT-type production environment is to balance flow of work; not capacity (see McManus[39]). To achieve this management policy, it is necessary to recognise the distinction between transfer lot size and process lot size. Transfer lot size refers to the quantity of parts to be moved between production resources. The process lot size refers to the quantity of items a production resource has to work on before a change of set-up is required. In an OPT-type environment, the execution of the policy will require a balance between transfer and process lot sizes, particularly, in the case of bottleneck resources.

To help produce a plan necessary for an OPT environment, one has to calculate appropriate lot sizes. One approach is to use a DSS with a specialised algorithm such as that developed by Goldratt[40]. Another approach is to use a DSS designed to support MRP/MRP II environment but by getting it to mimic the OPT effect. Details of the second approach is described in a paper by Swan[41]. In broad terms, this involves the iterative used of MRP and CRP algorithms.

3.4 The Proposed Generic Framework

The review of conventional CAPM systems, revealed the following factors:

a) All CAPM systems exhibit a hierarchical framework.

b) It is wrong to assume that technology itself actually defines a CAPM system *modus operandi* and the role of technology is simply a support mechanism.

c) The closed loop control framework applies to MRP II and OPT systems but not JIT, which is closer to the Mintzberg[29] model.

Having considered the factors listed above, a generic framework was devised based on the combination of the management models as listed in the Section 3.2. This strategy resulted in a proposed CAPM framework shown in Figure 2.

The proposed generic framework is based on three distinct types of modules:

a) Management modules;

b) Transaction process modules;

c) Database records.

3.4.1 Management modules

A management module corresponds to aspects of a CAPM system concerned with decision making. Using Simon's[42] model, a decision making process is characterised by three key phases; an 'intelligent' phase, a 'design' phase and a 'choice' phase.

The intelligent phase is concerned with identifying the existence of a problem. This aspect of the decision process is usually handled by a human with elements of a DSS (see Pounds[43] and Ewards[44]) to highlight the problem by indicating discrepancies between a planned and an actual phenomenon.

The design phase is where solutions to a problem is identified and/or devised. This is most likely to be handled by a human with elements of a DSS to help simulate consequences of solutions.

The choice phase is the selection of solutions. A management *policy* may be incorporated to define the scope of actions afforded to the human, who is responsible for the choice of solution.

Drawing from Simon's[42] decision model, the characteristics of a management module is expected to vary according to:

a) Management policy instituted;

b) Decision Support System (DSS) afforded;

c) User's role in decision making.

For a complex infrastructure like a CAPM system, it is unlikely that a single management module will cover all of its requirement. Drawing from the definition of a CAPM system as laid out in chapter one, the management modules have be identified as common to any CAPM system:

a) Master scheduling. This module deals with matters relating to the management of end-items and/or final assembly demands and due dates.

b) Capacity management. This module deals with matters relating to the medium term capacity planning and control.

c) Process planning. This module deals with matters relating to the planning and control of routings and set-up times.

d) Requirements planning. This module deals with the management of sub-assembly and component items demands and due dates.

e) Supplier sourcing. This module deals with the management of medium-term relationship between supplier and client.

f) Operations scheduling. This module deals with the short-term planning and control of due dates and throughput.

g) Supplier scheduling. This module deals with the scheduling of bought-out items.

h) Engineering change management. As the name implies, this module deals with the management of engineering change.

The choice of these eight modules is arbitrary but should, nevertheless, form a useful basis to study the functionality of any CAPM system.

3.4.2 Transaction processing module

A transaction is an activity like the transfer of materials. Often transaction records are needed to direct, report on or confirm a transaction. A transaction processing module corresponds to aspects concerned with producing transaction reports.

In any CAPM system, it is expected that there are eight types of transaction processing corresponding to the monitoring and dispatching of:

a) production orders;

b) purchase orders;

c) inventory and materials;

d) engineering change.

The characteristics of each TPS module is expected to vary according to:

a) transaction processing policy instituted;

b) Transaction Processing System (TPS) afforded;

c) User's role in decision making.

A transaction processing policy defines the way transaction processing is enacted. In other words, whether transaction processing is enacted in an on-line or manually.

A TPS is a system designed to support the processing and dispatching of transaction records. The TPS can be either fully computerised (thereby enabling on-line transaction processing) or partially computerised (where a mixed human-machine is used). The user model relates to the individuals who are responsible for the functioning of the TPS.

3.4.3 The Database

There is a precise meaning to the term 'data'. A data item refers to the symbols used to represent facts, knowledge, concepts and instructions of some enterprise(see ISO[45]). A collection of related data items is called a record. Data records are held in a database. A database is a repository of stored records. The enabling technologies for the management of databases ranges from simple paper filing systems to automated systems known as Database Management Systems (DBMS).

Any enterprise will require numerous records of data items but in broad terms, these records can be classified into three main groups:

a) *Master records.* These records represent information for identification purposes and are fairly static. The values of in these records do not change often.

b) *Operational records.* These records represents information for decision making and are fairly dynamic.

c) *Transaction records.* These records hold data about transactions and are very dynamic.

3.5 Chapter Summary

This chapter has shown that in order to fully comprehend the complexity of a CAPM system, its is necessary to appreciate the underlying roles of technological, human and policy elements that make-up the system. The purpose of the generic CAPM framework is to facilitate analysis in those terms.

The role of the policy elements (i.e. management and transaction processing) in any CAPM system is to define the limits of management decisions. In other words, it defines, for instance, how master scheduling is to be effected regardless of enabling technology. More to the point, it defines how enabling technologies are used.

The role of the technological element in a CAPM system is to provide support for decision making (i.e. DSS), transaction processing (i.e. TPS) and to act as a repository of information (i.e. database). In recognising the role of technology in this manner, this avoids the potential error of assuming that characteristics of a technology actually determines the operations behind a CAPM system. As indicated in this chapter, a software algorithm designed to enable calculations of requirements according to MRP principles can also be used to enable calculation along OPT principles.

Finally, the human elements in any CAPM system constitute the decision makers in the sense that they are responsible for the acceptance of any plans (i.e. schedules) generated. Whilst it may be technically possible for an automated decision making process, it is not necessarily what occurs in practice. Hence, the decision to consider the human users as part of the system infrastructure.

4. CRITERIA FOR CAPM EFFECTIVENESS AND EFFICIENCY

4.1 Chapter Introduction

The criteria for CAPM system effectiveness and efficiency, as indicated in Chapter 2, vary with one's point of view. In order to cater for a broad church of view of effectiveness and efficiency, it would be necessary to accommodate all possible views. The problem is what constitutes 'all possible views'? More to the point how practicable would it be accommodate every possible view in the CAPM audit methodology?

The approach adopted in this project was not to consider CAPM effectiveness and efficiency criteria from individual users' perspectives but from a much wider perspective. That means, approaching from the assumption that what ultimately counts in any company's performance is to achieve a sustainable competitive position. Whatever the infrastructures incorporated into a company the aim is to facilitate the achievement of a sustainable competitive position. Hence the effectiveness and efficiency of a CAPM system have also to be seen from that perspective.

Having identified the concept of competitiveness as a basis for the effectiveness and efficiency of a CAPM system, the question is how does one explain the impact of CAPM on competitiveness?

The purpose of this chapter is to discuss a theoretical framework to deal with that question.

4.2 The Concept of Competitiveness

4.2.1 Competitive forces

According to Porter[46], the state of competition in an industry is influenced by four basic forces, which are diagrammed in Figure 3. The collective strength of these forces is the prime determinant of a company's profit potential. The basic forces include:

a) Threat of new entrant.

b) Bargaining power of suppliers and buyers.

c) Threat of substitute.

New entrants to an industry bring new capacity and the desire to gain market share. The seriousness of the threat depends on the barriers present. Barriers can be manifested in several ways, for instance:

a) Product differentiation. Brand identification creates a barrier by forcing entrants to spend heavily to overcome loyalty.

b) Access to distribution channels. New entrants must secure channels of distribution. Thus barriers can be established by limiting channels of distribution.

Suppliers can exert bargaining power by raising prices or reducing the quality of bought-out items. Companies can become vulnerable to suppliers if they lack alternative sources or if suppliers have access to more than one customer. Likewise, buyers can also exert pressure on price, particularly when they can source from a significant range of alternatives.

Companies selling products with price-performance sensitivity can be threatened by substitutes with improved price-performance. To counteract the threat, companies can respond either by differentiation or by matching the new price-performance equation.

4.2.2 Generic competitive strategy

The preoccupation of each company is finding a position within its industry that will ensure above average performance. The basis of an above-average performance in the long run is *sustainable competitive advantage*. The significance of any company's strength and weakness, and its competitive position, is ultimately a function of its ability to adjust its cost structure and its ability to differentiate its products.

According to Porter[46], a company can seek sustainable competitive advantage through four generic strategies; cost leadership, differentiation, cost focus and differentiation focus. Each of the generic strategies involves a fundamentally different route to competitive advantage. The cost leadership and differentiation strategies seek competitive advantage in a broad range of industries, while focus strategies seek a narrow range.

4.3 Strategic Chains

To be in a position to fully appreciate the competitive position of a company, it is necessary to identify the mission of a company. An approach to recognising the mission of a company is to classify it. Two examples of effort to classify companies are represented by Woodward[47], Marucheck and McClelland[48]. However, these approaches have tended to be too narrowly focused and gives little or no real indication of a company's business mission.

For instance, in Woodward's[47] case, companies are reduced to entities of either 'unit', 'batch' or 'mass' production. Such descriptors do say something about the production technology deployed but not the mission of company, therefore, giving no clue as to what rationale the technology has in shaping a company's competitiveness.

Another approach is to classify the company according to its core competence; that is, in terms of product technology such as computer systems or aerospace systems. Whilst it is true that a company has core competence, the competitive forces acting on the company are not necessarily uniform. For instance, a company manufacturing personal computers and workstations will have core competence in computer systems. However, the nature of competition for personal computers and workstations is not necessarily the same. Generally speaking, personal computers are price sensitive whereas workstations are price-feature sensitive.

Thus, in order to identify what constitutes the mission or missions of a company, Ansoff[49], Gilbert and Strebel[50] stated that one must take into account all the activities that are necessary to deliver a product or service that meets the expectations of a market. These activities are variously referred to as 'value chain', 'business units' or 'strategic chain'. For this project the term 'strategic chain' is preferred. Therefore, rather than considering the company as competing in an industry, one should consider the strategic chain as competing in an industry.

4.4 The Criteria to Benchmark Competitiveness

It is impossible to define very specific criteria to cover all types of strategic chain. A more realistic approach is to use broad criteria. Hill[51] and Garvin[52], for instance, suggested that a set of benchmarks known as 'order winning criteria'. Examples of order winning criteria are:

a) Quality of design. This criterion is an indicator of the required product features.

b) Quality of conformance. This criterion defines the degree of conformance to specification as required by the market.

c) Delivery lead-time. This criterion defines the time a customer has to wait between the initiation of a customer order and the receipt of the finished goods.

d) Delivery reliability. This criterion defines the ability to deliver the product to within quoted time.

e) Volume flexibility. This criterion defines the ability to satisfy fluctuating volumes of demand without compromise to lead-time.

f) Design flexibility. This criterion defines the ability to produce product to customised requirements.

g) Price competitiveness. This criterion defines the ability to command for product value at a level acceptable to the market.

Order winning criteria provide useful information about the competitive position of a company's strategic chain in its chosen market environment. Those criteria, however, do not indicate if a competitive position is sustainable or not. Hence, another set of criteria is needed. Drawing from works by Howell and Soucy[53], the following criteria have been identified:

a) Inventory turnover. This criterion is used to identify the total cost of inventory incurred by a company.

b) Availability and reliability of suppliers. These criteria relate to Porter's[46] point on the power of supplier and the extent to which a company has effectively lock-in their supplier to its strategic chain.

c) Production lead-time. This criterion is a useful indicator of a company's ability to meet delivery requirements.

d) Utilisation of bottleneck resources and the availability of non-bottleneck resources. These criteria have implications on inventory and throughput. As Goldratt and Cox[54] pointed out, maximum utilisation of non-bottleneck resources results in overproduction whereas poor utilisation of bottleneck resources reduces throughput efficiency.

For want of a term, the second set of criteria is called 'manufacturing liabilities'. The term simply describes the degree of liabilities carried in helping to establish a competitive position. By combining, order wining criteria and manufacturing liability criteria an external and internal view of competitiveness is established.

4.5 Chapter Summary

The argument as presented in this chapter is that the effectiveness and efficiency of a CAPM system is best appreciated by its contribution to a company's competitive position. Also this contribution must be viewed not from the basis of a company unit but from the perspective of strategic product chains. The competitive position of each chain is benchmarked by two sets of criteria; 'order wining criteria' and 'manufacturing liabilities'. One of the design goals of the CAPM audit is to emphasise these concepts.

5. JUSTIFYING THE NEED FOR A NEW METHODOLOGY

5.1 Chapter Introduction

Several candidate methodologies were identified and reviewed in order to establish if there was justification for a new methodology. The candidate methodologies were extracted from several sources. Here, it is useful to distinguish between the terms 'methodology' and 'source'. A methodology is defined as a system of methods and principles for the auditing of CAPM system, whilst a source refers to methods and principles that may have relevance to the evaluation of CAPM system but not necessarily specific to a CAPM system *per se*.

The purpose of this chapter is to highlight the strengths and weaknesses of candidate methodologies and the lessons drawn from them are used to justify the development of a new methodology.

5.2 The Search for Candidate Methodologies

5.2.1 The Search Method

The search for candidate methodologies had two key considerations:

a) how to ensure a representative sample of sources and, by implication, methodologies?

b) how to extract relevant methodologies from sample sources?

To ensure a representative sample of sources, the search area was targeted at several specialist interests; operational research, management theories, management accounting, and software engineering.

The underlying methodology in each source were extracted through pair-wise classifications.

5.2.2 An Overview of the Candidate Methodologies

Category I. This category is represented by sources using the Delphi technique.

Frizelle[55] introduced a CAPM system implementation methodology consisting of three stages. The first stage facilitates the evaluation of obstacles to the implementation of CAPM systems. The framework in this stage is based on a series of structured questions aimed at identifying resistance to change and the extent of financial resources available to implement change. The second stage evaluates the installed CAPM system by considering issues of functional integration and data accuracy. The last stage is structured to enable the analyst to see the logical trails of previous stages and to use the trails as a basis to identify one or several scenarios of optimum CAPM systems based on a list consisting of project management, simulation-type system, MRP, JIT to OPT.

Platts and Gregory[56] proposed a so-called manufacturing audit approach to support the development of a manufacturing strategy. Their manufacturing audit consists of three stages. The first stage supports the evaluation of how well a company is performing in its market and the threats and opportunities confronting it. The second stage supports the evaluation of the strength of the company's structure (i.e. plant layout) and infrastructure (i.e. CAPM systems). The third stage is designed to enable the analysts to use information from stages I and II to draw one or several plausible manufacturing strategies.

Rowan and Chatterton[57] proposed a 'production audit' methodology, which they used to evaluate both structural (production facilities) and infrastructure (organisation, information system) of a company. The methodology requires a multi-disciplinary team of specialists to address issues within the realm of their expertise. An audit outcome is then produced by collating the findings of the specialists.

Category II. This category is represented by sources using quantitative techniques.

Chandler[58] proposed a method for evaluation of the service performance of computer based information systems. The method involves decomposing the services of computer systems into activities. A service refers to the outcome expected by the user; such as, the search for a file. The search for a file is usually composed of activities like authentication, locating and retrieval. Performance of such a service is established by comparisons between estimated (sum of calculated activity times) and actual service cycle times.

Bard[59] presented a method aimed, principally, at analysing the effects of system automation. The approach involves decomposing a system into sub-systems. Each of the subsystems is then mathematically linked with a series of functional criteria, such as costs, reliability and safety. The mathematical link is achieved by a technique known as non-linear multi-objective integer programming. The completed model is then subjected to variations in the subsystems' characteristics and the effect on functional criteria noted.

In all the sources uncovered under this category, the only direct application of scientific technique to CAPM audit is by Hicks. His approach to CAPM audit involves the use of a tool, designed to operate on strict simulation principles, to test the effects of plant layout, scheduling rules and data update frequencies. According to the report by Hicks et al[60], the simulation tool has three key components. The first component consists of modules not dissimilar to those found in typical MRP-type CAPM systems. This allows a simulator user to generate production plans. The second component consists of modules generating random conditions to effect plans generated by the first component. The third component provides modules to conduct regression and sensitivity analysis.

Category III. This category is represented by sources associated with software engineering. Software engineering refers to a disciplined approach to analyse software requirements and the crafting of software systems. Many methods have been developed. All of these methods have two basic components; a paradigm and a set of notations.

The function of the paradigm is to enforce an orderly software development process in accordance with prescribed programming principles. Broadly speaking, software systems can be sub-divided into three basic paradigms.

a) Logic analysis. An example of the method enforcing this paradigm is GRAI (see Ridgeway[61]).

b) Structured analysis. Examples of methods enforcing this paradigm include SSADM and SADT (see Bravoco and Yadav[62])

c) Object-orientation. Examples of methods enforcing this paradigm include Coad and Yourdon[63].

The notations, as used in software engineering, function as graphical and/or textual vocabularies for system modelling.

Category IV. The sources identified in this category represent the use of 'ratio analysis' for information system evaluation.

Buker's[64] work is intended specifically to evaluate MRP II systems. There are three identifiable stages. Firstly, the method involves identifying outputs generated by the systems. Secondly, system outputs are expressed as ratios of real to ideal outputs. Thirdly, the calculated ratios are discriminated on a scale corresponding to Wright's[65] classification. For example, a CAPM system is judged to be class A if the overall performance ratio is rated at 90% or better.

Matlin[66] propose a method not dissimilar to Buker's[64]. In Matlin's[66] case, calculated ratios are compared with an industry ratio. In other words, determining if a company's ratio is above or below the average ratio when compared with a similar group of companies.

Category V. The sources in this category represents techniques which seek to measure CAPM system compliance to some prescribed norms.

Cook[67] formulated a checklist of best practice criteria, against which CAPM systems are to be measured. The checklist is deliberately structured to emphasise the MRP II framework as the best practice.

Hansen and Hill's[68] proposal was a checklist to enable the evaluation of good practice in the context of electronic data interchange systems. The checklist does not apply directly to CAPM systems and it emphasises good practice only on issues of data accuracy.

Miller and Dunn[69] provided a list of pointers on how to subscribe to sound MRP principles. Those principles can then be used to establish a good practice norm.

Category VI. This category is represented by sources that use financial techniques to evaluate CAPM system.

Keen[70] described an approach to establish CAPM system effectiveness and efficiency using a pseudo 'return on investment' type analysis. The approach requires, firstly, operational measures of performance to be defined (e.g. reduction in costs, due date performance). The values of the defined measures are then used to decide on a *quid pro quo* basis, if the cost of CAPM implementation is justified. In other words, deciding if, say, a 10% improvement in customer satisfaction justifies a £10,000 CAPM installation.

Primrose[71] proposed a method similar to Keen's[70] in the sense that the value of information systems is calculated on the basis of return on investment. However, the former method requires all of the operational measures to be expressed in monetary form.

Category VIII. This category is represented by sources that seek to establish an appropriate match between CAPM system type and the context in which they operate.

Grünwald and Van Der Linden's[72] methodology used a network analysis technique to typify production or, more specifically, scheduling requirements. The next stage is to test the different classes of scheduling requirement against MRP, JIT and OPT using simulation techniques. The system that exhibits the best result is deemed the optimal solution.

Barber and Hollier's[73] work was concerned with identifying an optimal CAPM system for each company-type. Their work has two identifiable stages. The first stage involves applying numerical taxonomy on the following variables:

a) market/customer environment;

b) product complexity;

c) the nature and complexity of manufacturing operations;

d) supplier environments;

e) company structure and manufacturing policies.

The result of the first stage provides a classification of companies. In the second stage, an optimum CAPM structure is defined by making comparisons between successful and unsuccessful companies with each type grouping.

Boaden and Dale[74] proposed a method to evaluate Computer Integrated Manufacture (CIM). The method is based on a series of structured questions designed to elicit users' expectations of CIM. The performance of each existing system is established by comparing the user's expectation and the characteristics of the system installed.

McGarrie and Kochhar[75] developed a methodology consisting of two stages. The first stage involves the establishment of the uncertainty, complexity and flexibility attributes in a given manufacturing system. In the second stage, the methodology recommends a CAPM system from a range that include Order-point, MRP, MRP II, Kanban and OPT systems. The selected CAPM system is one that will satisfy the attributes of the context in which it is to operate.

5.3 Analysis of Candidate Methodologies

5.3.1 Method of analysis

For this project, the issue of whether a candidate methodology is appropriate rests on how well it addresses these questions:

a) Is the methodology flexible enough to cope with the problems in a partial audit scenario?

b) Does the methodology engage the client in the audit?

c) Does it support the concept of competitiveness as the basis for CAPM effectiveness and efficiency?

d) Does the methodology address the problem of CAPM systems at an appropriate level of abstraction?

These questions follows from the requirements of a CAPM audit outlined in Chapter Two, Chapter Three and Chapter Four.

5.3.2 Result of Analysis

The result of the analysis is summarised in Table 1.

Category I. The sources in this category will easily satisfy the criteria on flexibility and a team-oriented approach. One methodology, by Platts and Gregory[56], offers useful clues to enable the evaluation of CAPM systems from the perspective of their impact on competitiveness. The other methodologies are lacking in their emphases on competitiveness and how CAPM system can impact it. However, all methodologies fail in terms of abstractions; they treat CAPM system as abstractions of either MRP, MRP II, JIT or OPT. The major problem with those abstractions is that they hide the underlying source of failure by not recognising that the CAPM system is a complex aggregates of social as well as technological factors.

Category II. From the perspective of criterion-related validity, one could argue that quantitative techniques offer a highly objective methodology. Objective in the sense that quantitative techniques require the use of hard measures that can be verified. However, the emphasis on hard measures does restrict its application in a partial audit scenario where access to data may be restricted.

From the perspective of construct validity, quantitative techniques offer a transparent way of testing constructs of CAPM system failure. Transparent in the sense that the trail leading to the conclusion of CAPM failure can be traced and repeated without biases.

The level of abstractions that these candidate methodologies handle is also very restrictive. Chandler's[58] methodology restricts analysis to issues of data accuracy, Hick's technique[60] is restricted to MRP II type CAPM systems and Bard's[59] technique to problems that can be represented in multi-objective linear programming, none of which meets the requirement of a CAPM audit.

None of the candidate methodologies dealt specifically with the question of competitiveness.

Finally, these methodologies are not appropriate for a team-oriented audit approach. This problem is inherent in quantitative techniques in that they require highly specialised vocabularies.

Category III. These methodologies are useful for the modelling of CAPM systems in an orderly fashion and they lacks any reference to any particular technology. They are also generic in the sense that they can facilitate abstraction of any potential CAPM system to any depth. However, any resulting model of a CAPM system is severely restricted to the semantics of the modelling notations and it will require expertise to manage the methodology. This drawback will likely hinder a team-oriented approach to auditing. In terms of its applicability to a partial audit scenario, there are no clear criteria to suggest that the methodologies are inappropriate. What is clear is that the candidate methodologies lack explicit reference to the issues of competitiveness.

Category IV. These methodologies seemed to provide objective information. However, unless the ratios are properly dimensioned, the methodology offers little in appreciating the rationale for system failure or otherwise. Also, the highly structured procedure makes the methodology inappropriate in partial auditing scenarios.

Category V. These methodologies raise questions about their construct validity. Particularly since they are aimed at measuring systemsagainst prescribed 'good practice' benchmarks, one has to ask; what is good practice?

These methodologies could also have the effect of drawing conclusions to a particular prejudice rather than actually reveal why an installed system has failed.

Category VI. The methodologies in this category approach the evaluation of the impact of CAPM systems in monetary terms and will provide an attractive expression of value. However, getting the information to verify the monetary value of a system will present a significant challenge in partial audit scenarios.

Category VII. The construct validity of these methodologies is questionable. These methodologies relies on statistical correlation to establish CAPM system types (i.e. MRP, JIT, OPT) against company type. This raises two basic questions:

a) These correlations are established at a very high level of abstraction, so can they pin-point failure of real life systems?

b) How accurate are the variables used to classify companies?

5.4 Chapter Summary

The search for candidate methodologies revealed alternatives, which falls into seven broad categories; Delphi-type technique, mathematical techniques, software engineering techniques, ratio analysis, 'good-practice' benchmarking, financial analysis, and qualitative optimisation. These approaches, on their own, were found to be unsuitable in both methodological and practical terms. However, they have certain strengths. Hence, the project strategy is to build upon the strengths of the alternatives identified in this chapter instead of creating an audit from scratch.

6. DESIGNING THE CAPM AUDIT

6.1 Chapter Introduction

A CAPM Audit has been created from the principles described in the previous chapters. The purpose of this chapter is to describe the design decisions involved in translating the principles into a working framework.

6.2 The Proposed Audit Framework

Lessons from the analysis of the problem of auditing and the exploration of candidate methodologies suggest a team-oriented approach for the CAPM audit as the best option. However, several problems were identified in a team orientated approach. Firstly, there is the problem of delegation. Secondly, there is the problem of ensuring a cohesive audit process.

To address those problems, it was decided that a four stage audit framework would be the best basis for a CAPM audit. The four stages are:

a) Stage I - Establish the context;

b) Stage II - System analysis;

c) Stage III - Impact analysis;

d) Stage IV - Problem analysis.

A functional model of the framework is shown in Figure 4.

The overall design strategy calls for a workbook-based support mechanism. The workbook is to consist of worksheets to facilitate the creation of audit trails. The choice of a workbook-based mechanism is based on two considerations:

a) a framework to facilitate ease of methodology transfer;

b) a flexible medium to ease the creation of audit trails.

6.3 The Design of Stage I

The design goal called for a framework to help the audit team analyse a company from the perspective of strategic chains. What the audit team has to do in this stage is to examine three groups of characteristics associated with each chain:

a) Group I characteristics relate to sales revenue, contributions, growth potential, market share and potential competitors. By analysing the strategic chains in these terms, the intention is to reveal the value of each chain and, hence facilitate the determination of the weighting of the impacts which the CAPM system should deliver.

b) Group II characteristics relate to the product position, product structure, number of components, and the percentage of bought-out items associated with each chain. The intention here is to reveal the nature of the product associated with each chain and, therefore, the complexity of the production management environment.

c) Group III characteristics relate to the organisational structure of the company. The intention here is to reveal the scope required of the CAPM system.

Three worksheets have been designed to support the tasks in this stage. The worksheets are designated 1.1, 1.2 and 1.3. Worksheet 1.1 is intended to capture information relating to Group I criteria, Worksheet 1.2 that relating to Group II criteria and Worksheet 1.3 that relating to Group III criteria. All three worksheets, whilst designed to capture and retain different types of information, share the same structure. A schematic of the worksheets is illustrated in Figure 5.

Each worksheet consists of a series of rows and columns. Each row defines a strategic chain based on an identified product family. Each column identifies a particular characteristic about the strategic chain.

6.4 The Design of Stage II

The design goal for this stage was for a framework to enable the comparison of any installed CAPM systems from the perspective of the generic CAPM framework defined in chapter three. This approach represents a CAPM system as comprising of management modules, transaction processing modules and a database.

Management modules. The design strategy here is to explore issues of policies (i.e. rules on how decisions are processed), DSS capabilities and user characteristics.

Transaction processing modules. The problems of transaction processing can frequently be attributed to a mismatch between processing capabilities and the volume of data to be processed. Therefore, the design strategy here was facilitate the investigation of transaction volumes, transaction policies (i.e. rules on how transaction processing is to be instituted) and the capabilities of the TPS.

Database. The design strategy here is to consider issues relating to the integrity, concurrency, data accuracy and data independence of the CAPM database. Using the terms and definitions by Date[76], four criteria are as follows:

a) *Integrity.* This is an indication of the completeness of a database. In other words, whether a database has completely captured all of the facts and knowledge it is supposed to represent.

b) *Concurrency.* This is an indication of a database ability to support multiple access to the same data value.

c) *Data accuracy.* This is an indication of how contemporaneous the database is when measured against the facts the system is supposed to represent.

d) *Data independence.* This is an indication of how amenable the database is to technological changes.

Three different worksheets have been designed to support this stage. The worksheets are designated 2.1, 2.2 and 2.3. In the design of the worksheets, two design alternatives were explored:

a) Alternative I - Establish a system of worksheets to facilitate graphical modelling.

b) Alternative II - Establish a system of worksheets to facilitate modelling in normal English.

Alternative I would have necessitated the provision of graphical notations to represent the characteristics of any CAPM system. This would require very significant design effort plus a considerable effort to communicate the syntax of the sets of graphical notations to the user, thus adding to the complication of methodology transfer. Since English is a common form of communication, Alternative II would present less problem for methodology transfer, although it is recognised that textual input is frequently not exact.

Worksheet 2.1 is designed to hold information relating to the management modules in a CAPM system. The worksheet consists of six segments to be completed (see Figure 6). Segment {1} requires the name of the particular module being examined (i.e. master scheduling, capacity planning, etc.). Segment {2} requires the name of any product family(ies) affected by the module. Segment {3} requires a description of the management policy. Segment {4} requires a description of the DSS that forms part of the module being examined. Segment {5} requires a description of the user (i.e. decision maker and support staff) that forms part of the module. Segment {6} requires a convenient designator (i.e. user define code) to identify the user involve.

Worksheet 2.2 is designed to hold information relating to transaction processing modules in a CAPM system. This worksheet has seven segments (see Figure 7). Segment {1} requires the name of the particular module being examined (i.e. dispatching jobs, monitoring purchase orders). Segment {2} requires the name of the product family(ies) affected. Segment {3} requires the number of transactions involved. Segment {4} requires a description of the transaction processing policy instituted. Segment {5} requires a description of the TPS. Segment {6} requires a brief description of the user involved. Segment {7} requires a convenient designator to identify the user involve.

Worksheet 2.3 is designed to enable an auditor to note the update interval, accessibility and record medium of each data record type from the perspective of a particular CAPM user. A schematic of the worksheet is shown in Figure 8. Items of information should be presented as follows:

a) Segment {1} will have an indication of the product family(ies) affected.

b) Segment {2} will have an indication of the update interval of record 1 from the perspective of User 1.

c) Segment {3} will have an indication of the accessibility of record 1 from the perspective of User 1.

d) Segment {4} will have an indication of the medium in which record 1 is held from the perspective of User 1.

Note that the user designation should correspond with those identified in worksheets 2.1 and 2.2.

The design of Worksheet 2.3 is restricted to the analysis of ten record types:

a) Item master;

b) Work centre;

c) Statistical;

d) Master schedules;

e) Requirements plans;

f) Process plans;

g) Inventory status;

h) Shop floor status;

i) Purchase order status;

j) Engineering change status.

This list of record types is considered representative of the basic types found in any CAPM system.

6.5 The Design of Stage III

The design goal required a framework to enable the exploration of the strategic chains of a company as the target components of a CAPM system. This means that the competitive position of each chain is established as the basis on which the impact (i.e. the effectiveness and efficiency) generated by a CAPM system is determined.

The competitiveness of each chain shall be benchmarked against order winning criteria and manufacturing liabilities.

The framework was also required to be designed in such a way that it allowed the audit team to use whatever measures, direct or surrogates, which were available as long they correlated with the criteria listed in chapter four. The rationale behind this design decision was to attempt to ensure flexibility.

For the purpose of audit trail, the audit team must also quantify the competitiveness on a standardised scale. The idea of presenting findings on a standardised scale is to enable the clear communication of the magnitude of each measure. Several candidate scaling systems were considered. Principally these were the Likert scales, Guttman scale and semantic differential scale.

The Likert scales, also called summated scales, are commonly used in the social science research community (see Torgerson[77]). The scaling system consists of a set of statements which reflects favourably or unfavourably on a particular attitude. For instance, for this project, a statement like "the company's inventory-turn measure is satisfactory" could be formulated and the respondent could then register if they agree or disagree with that statement. To be more sophisticated the agreement or disagreement categories can be expanded to indicate shades of agreement or disagreement. The problem with this approach is having to establish the number of statement sets per criterion of CAPM system effectiveness and efficiency. The number of performance criteria involved would have entailed very significant design effort.

The Guttman scale is intended to enable the scaling of qualitative data but also to reduce the effect of inaccuracies caused by distractions or inconsistencies (see Guttman[78]). For such a scale to work, will require not just one but several like-minded individuals to provide their binary (i.e. good or bad) responses to a statement about a measure. The sample of responses will enable the identification of consistency. However, it will also be necessary to ensure that any results are not just a product of chance. Thus, the measure will have to be correlated with one or more control statements.

The semantic differential scale consists of a set of bipolar adjectives with, usually, a seven point scale between the adjectives (see Osgood[79]). A concept is presented to the respondent and all that he or she has to do is to mark off on the scale which adjective is clos~~e~~est in meaning. For instance, a respondent could be asked to indicate if the price of goods he is selling is low or high as compared to the competition.

Clearly, both Likert and Guttman scaling systems require significant design effort. They also do not facilitate, say, results of order winning criteria to be expressed in one broad format. The auditor can only view the criteria one-by-one.

With the semantic scaling system, it is possible to see and deal with multiple criteria in one broad format, which is very useful in providing clues to possible coupling in criteria that may exist. Hence, the decision was to design a worksheet based on the principle of semantic scaling.

6.6 The Design of Stage IV

The design goal calls for a Delphi framework to identify the weakness of the installed CAPM system. The Delphi framework is a form of structured consensus analysis. The structured aspect of the framework means that the audit team is expected to substantiate their final result based only on evidence from the previous stages. The consensus aspect implies a team-oriented analysis.

Initially, it was felt that this stage of the audit could benefit from using the mechanism found in the methodology of Platts and Gregory[56]. The advantage of that format is its ability to enable an auditor to construct multiple correlations between components of CAPM systems and the competitive dimensions (i.e. order winning and manufacturing liabilities criteria). The disadvantage was its fixed structure, which restricts the amount of information that can be held. Although its design was intended to enable group discussion, the fixed structure does not allow for alternative views to be captured easily.

For the CAPM audit, it was decided that the design of the framework be based on the Ishikawa's[80] 'fish-bone' concept. It provides a simple approach to present the correlation between 'cause' and 'effect'. The fish-bone framework is flexible enough to enable the audit to accommodate as much detail as required. Its flexibility would also be such that alternative views on single causal factors can be captured, thus, making it more natural for group discussion. Most importantly, the 'fish-bone' concept is a relatively mature framework. It is widely used, particularly in quality control, so it should be fairly familiar to any potential auditor or client, thereby, easing the use of the CAPM audit methodology.

6.7 Chapter Summary

It was decided to structure CAPM audit into four key stages. The structure was designed to ensure that the audit would be manageable in the context of a team-oriented approach.

It was also decided to support the audit by a workbook. The choice of a workbook support mechanism is based on two main considerations:

a) to facilitate ease of methodology transfer;

b) to facilitate the creation of audit trails.

The proposed CAPM audit framework is presented in workbook form in Volume II of this thesis.

7. AUDIT EVALUATION

7.1 Chapter Introduction

The CAPM Audit was subjected to a series of trial runs. The mission of the trial was to determine if the audit design goals, as described in chapter six, could be met in real life scenarios.

The purpose of this chapter is to describe the trial proceedings and lessons gained from the trials. It is not the purpose of this chapter to present conclusions about the companies involved in the trials.

7.2 Method of Evaluation

7.2.1 The terms of reference

For the purpose of the trials, six collaborating companies were chosen as case clients. The nature of the companies is as follows:

a) **Client A.** This client generates an annual sales turnover of £10m. It has approximately 200 employees, and manufactures medium scale industrial bearings.

b) **Client B.** This client generates an annual sales turnover of £60m. It has approximately 300 employees, and manufactures large scale cranes and winches.

c) **Client C.** This client generates an annual sales turnover of £450 K. It has approximately 10 employees, and manufactures a wide range of customised jigs and fixtures.

d) **Client D.** This client generates an annual sales turnover of £19m. It has approximately 300 employees and manufactures fabricated steelworks.

e) **Client E.** This client generates an annual sales turnover of £15m. It has approximately 300 hundred employees. Its core businesses are the manufacture large internal combustion engines and turbines.

f) **Client F.** This client generates an annual sales turnover of £25m. It has approximately 200 employees. Its core businesses are the manufacture of large power transformaters and electrical machines.

The chosen clients were considered 'worst case' scenarios for the following reasons:

a) These companies had complex environments that cannot be described by simple company or manufacturing classification (e.g. MTO, batch, or volume). This presents significant challenges in establishing the requirements for the CAPM system.

b) These companies had highly fragmented CAPM systems in software, hardware and architectural terms. Hence, it is difficult to classify their systems within the more conventional categories of MRP, MRP II or JIT.

c) These companies had little or no formal strategy for CAPM system evaluation. This presents a potential problem with the collection of data necessary for the evaluation of such systems.

The terms of reference for the conduct of the trials were as follows:

a) The whole audit proceedings, from initiation to submission of the audit report, would be restricted to a period of no more than two months.

b) Access to information would be restricted to that specifically permitted by the client.

These terms of reference were conditions considered typical of a partial audit environment.

7.2.2 Trial procedure

The audit was applied according to the procedure described in the CAPM audit workbook (see Volume II) in each of the six chosen scenarios. The difficulties encountered in the application of the procedure were evaluated.

Since the audit is composed of four independent stages, each of the stages was evaluated according to its particular objectives.

7.3 Evaluating Stage I of the CAPM Audit

7.3.1 Trial objective

This stage of the audit requires the auditor to perform the following tasks:

a) Identify the range of products which each company manufactures, and then classify the range into families. Each family identified shall then form the basis of the company's strategic chain.

b) Establish the relative commercial value of each chain according to the procedure defined in worksheet 1.1 of the workbook.

c) Establish the manufacturing complexity of each chain according to the procedure defined in worksheet 1.2 of the workbook. The completed worksheet is then expected to provide knowledge of the information necessary to enable production to be controlled.

d) Establish the organisational infrastructure assigned to each chain as defined in worksheet 1.3 of the workbook. The completed workbook is expected to provide knowledge about the scope of manufacturing and the management framework (i.e. whether the chains are managed independently or together).

Descriptions of the procedures associated with worksheets 1.1, 1.2 and 1.3 are found in pages 1 to 6 of the workbook.

The trial objective here was to identify any difficulties in complying with the prescribed procedure.

7.3.2 Case scenarios

The trials were conducted under the following circumstances.

Client A. This client has three recognisable product families:

a) Marine bearings;

b) Industrial bearings;

c) Ball/Roller bearings.

The products in all three families were made-to-order. The structure of products for family (a) and (b) are fairly deep (i.e. between 6 to 10 levels in BOM terms). In the case of (c), the structure is shallow (i.e. 1 to 5 levels in BOM terms).

All products share the same production resources and are manufactured on a single site.

The client's management structure is illustrated in Figure 9, which suggests a common production management framework.

Client B. This client has four recognisable families of product, which are known as 'main contracts', 'subcontracts', 'spares' and 'mini stand-alone business'. The nature of each product varies considerably:

a) Main contracts are Engineer-To-Order (ETO) products with very deep product structures.

b) Subcontracts are Made-To-Order (MTO) products with varying product structures (i.e. ranging from very shallow to very deep).

c) Spares are Made-To-Order (MTO) products with very shallow product structure.

d) 'Mini stand-alone business' are Made-To-Stock (MTS) products with very shallow product structure.

The client's organisational structure consists of seven autonomous business units (see Figure 10). Each unit manufactures a combination of product (a), (b) and (c). Only one of the unit is dedicated to the manufacture of unit (d).

Client C. This client does not have recognisable families of product. Instead the client categorises its business according to the type of relationships enjoyed by its customer. These classifications equates to:

a) Regular customers are those with long term subcontracting relationships.

b) Irregular customers are those with fairly long term subcontracting relationships.

c) Rare customers are those with only one-off subcontracting relationships.

All products are MTO type with structures varying from very shallow to shallow.

All products are manufactured on a single production site.

This client management structure is shown in Figure 11, suggesting a single management framework for all products.

Client D. This client has three identifiable product families:

a) Steel bridges and other welded fabrications;

b) Beam and column steelworks for buildings;

c) Water storage tanks.

All products are ETO or MTO. All products have fairly deep product structures.

Production is distributed across two independent sites but the management structure shown in Figure 12 suggests a single management framework for all products.

Client E. The client's family of products comprises:

a) Diesels engines;

b) Steam turbines;

c) Spares.

All products are engineered to order. Products in family (a) and (b) have very deep product structure, whereas (c) has very shallow product structure.

Production is distributed across two independent sites but the management structure as shown in Figure 13, suggests a single management framework for all products.

Client F. This client has three identifiable families of products:

a) Power transformers;

b) Electrical machines;

c) Distribution transformers.

Power transformers and electrical machines are engineered to order, whereas distribution transformers are assembled to order. All products have fairly deep product structures.

The client is a confederation of two autonomous business units (see Figure 14). Each unit has its own separate manufacturing and production management framework. One unit is dedicated to the manufacture of power transformers and the other is dedicated to the manufacture of electrical machines and distribution transformers.

7.3.3 Result of evaluation

The items of information necessary for this stage of the audit were generally accessible. The only problems encountered were:

a) The identification of product families for Client C.

b) Completing worksheet 1.3

Point (a). The difficulty of Client C was that there were no clear product families, which initially seemed to suggest that only one family was involved. However, on further reflection it was noted that some kind of product differentiation was in place, except that it was not based on items of manufactured goods. Instead the concept of product differentiation should be seen in terms of services provided. This approach could not be detected in the audit procedure as originally proposed.

Point (b). Worksheet 1.3 requires the auditor to identify a business unit as the area where manufacturing and production management occurs independently. The worksheet was designed to assume that a company may have the option of assigning a number of strategic product chains to a single manufacturing unit or to assign one unit for each chain. The assumption was appropriate only for clients A, B, C and F. In the cases of D and E, the assumption was invalidated by the fact that, whilst the companies had established different sites for specialised production processes, all of those different sites shared the same production management framework. Therefore, the concept of a business unit had to be redefined in the audit.

7.4 Evaluating Stage II of the Audit

7.4.1 Trial objective

This stage of the audit requires the auditor to analyse the CAPM system by comparison with a generic framework. The audit procedure is as follows:

a) Identify the management modules, transaction processing modules and database modules of the installed CAPM system.

b) For each of the modules analyse its characteristics as defined in worksheets 2.1, 2.2 and 2.3 which are provided to support this task (see pages 7 to 22 of the workbook).

The trial objective was to determine the difficulty of complying to the prescribed audit procedure.

7.4.2 Case scenarios

The management policies for all of the collaborating companies are as noted in Table 2. In general most companies had no formal policy for master scheduling, process planning, and vendor scheduling. However, only one company had no formal policy for capacity management, and the same company had no formal policy for requirements planning, An assessment of the hardware and software provisions in each collaborating company is as follows:

Client A. The CAPM system was based on a combination of stand-alone Personal Computers (PC) and a Mainframe system. The mainframe supported MAAPICS. The client's PC supported in-house developed software, process planning software and a CAD system. Information on software features were obtained from informal discussion with CAPM users and observations of system operations.

Client B. Like its corporate structure, the client's CAPM systems were also fragmented. Each individual unit maintained their own CAPM system. The only common thread was that all units used a mixture of mainframe and PCs. The mainframe supported an MRP II-type system (developer unknown) whilst the PCs supported in-house developed systems.

Client C. The installed CAPM system was a combination of PCs based and manual systems. The software, in-house developed, supported basic stock control and transaction processing.

Client D. The CAPM system was based on a collection of PCs, some networked, the majority being stand-alone. The PC supported a vendor system known as EFACS and several in-house developed software programs. Knowledge about EFACS was obtainable from user guides. Knowledge of the in-house developed systems was difficult to obtain as there was no documentation and the system developers were not available for interview.

Client E. The client uses a mixture of stand-alone PCs and a Mainframe. The mainframe supports MRP II-type software modules. The PCs support transaction processing and process planning software modules. The systems were obtained from separate vendors.

7.4.3 Result of evaluation

Worksheet 2.1. This worksheet requires CAPM users to supply information relating to policy and DSS characteristics.

Most CAPM users were unable to articulate the policy element of each module. One possibility for this could be that the choice of CAPM users was inappropriate. The other possibility that this could have been due to:

a) A lack of written policy statements.

b) The application of *ad hoc* policy.

A lack of written policy did not necessarily imply that there was no policy. It was suggested by the CAPM users that unwritten rules, usually in the form of 'rule of thumb', were applied. For instance, in the majority of the cases, a shortest lead-time policy was instituted for operational scheduling problems and none of this was noted as official policy .

The trial also noted that *ad hoc* policies were often applied. *Ad hoc* policies are those which are capable of being adjusted according to circumstances. For example, it was noted that the collaborating companies tended to change policy when there was a change in a key decision maker.

The problem encountered in the trial was identifying and differentiating between 'rule of thumb' policies and *ad hoc* policies.

The difficulty of the task of establishing the characteristics of each DSS varied significantly. In a situation where 'off-the shelf' systems were used, it was possible to rely on user-guides, sales brochures and interviews with vendors to obtain appropriate information. However, the in-house developed systems proved problematic because there were no written materials for reference. Even the users of these systems were not necessarily aware of the capability of their systems.

Worksheet 2.2. There were considerable problems in supplying measures for the criterion; 'number of transactions'. This was partly due to confusion as to what constituted a transaction.

Worksheet 2.3. The problem at this point related primarily to semantics. For instance, the audit required the auditor to analyse the 'statistical records' component of the client's database. However, the collaborating companies had difficulties in establishing the meaning of the phrase 'statistical records'.

7.5 Evaluating Stage III of the Audit

7.5.1 Trial objective

This stage of the audit requires the auditor to calculate the impact of the installed CAPM system on the client's competitiveness. The prescribed audit procedure is as follows:

a) Identify measures that correlate with the criteria listed in worksheet 3.1 of the workbook. Then benchmark each measure with an appropriate basis for comparison.

b) Identify measures that correspond with the criteria listed in worksheet 3.2 of the workbook. Then benchmark each measure with an appropriate basis for comparison.

(Descriptions of Worksheets 3.1 and 3.2 are in pages 23 to 28 of the workbook).

The aim of the trial was to identify problems experienced in completing this stage according to the prescribed procedure.

7.5.2 Case scenarios

The trials were applied under the circumstances as summarised in Table 3 and Table 4.

7.5.3 Result of evaluation

The most significant problem encountered during this stage of the trials was to establish measures for each of the performance criteria within the time frame which was agreed at the onset of the trials' terms of reference. With the exception of client C, the audit team could only sample about 20% of the required measures for benchmarking for all the other collaborating companies. Ideally, a sample size of 70% would offer a more reliable and possibly statistically valid result.

The key reason for the inability to produce an ideal sample size could be attributed to the virtual absence of information, in most cases, and therefore the need for extensive 'walk through' analysis. Walk through analysis here refers to a process of reconstructing data from the raw form. For instance, in the calculation of inventory turnover, one could produce estimated measures by investigating the production costs. The limited time frame conspired against completion of this walk through analysis.

7.6 Evaluating Stage IV of the Audit

7.6.1 Trial objectives

This stage requires the auditor to identify any weaknesses in the installed CAPM system. The prescribed procedure is as follows:

a) Several independent experts are asked to individually produce their correlations between the installed CAPM system modules and the performance criteria (as listed in worksheet 3.1 and 3.2) on worksheet 4. The experts are constrained to identify correlations based only on evidence obtained during stage one, stage two and stage three of the audit and nothing else.

b) Having presented their individual viewpoints, the experts are then expected to challenge each other and then draw up a consensual view.

The prescribed procedure is detailed in the workbook in volume 2, pages 29 to 30.

The aims of the trial in this stage was to determine any difficulties in the completing the audit according to this procedure.

7.6.2 Case scenarios

A team of experts, chosen from the collaborating companies, was asked to complete Stage IV and their reactions noted.

The team was also asked to respond to a set of structured questions about the CAPM audit framework. The survey questions (see Appendix A) were structured to establish their attitude towards a number of factors:

a) Factor A. The ability of the audit to reveal the client's competitive position.

b) Factor B. The ability of the audit to help establish the client's CAPM system characteristics in a holistic manner.

c) Factor C. The ability of the audit to help establish the correlation between the client's CAPM system and its impact on competitiveness.

The survey involved participants of the audit proceedings, with the expertise as summarised in Table 5.

7.6.3 Result of evaluation

The result of the survey is summarised in Table 6.

The trials indicated that there was a tendency to drift substantially beyond the scope of the audit. The drift contributed significantly to a perceived miss-match between Stage IV and previous stages by highlighting problems that had no substantive audit trails. The drift could also be attributed to problems of having to cope with the mass of audit trails generated and the difficulty to draw inferences within the prescribed time frame. This may also have contributed to the poor level of agreement (33% of survey respondents) that Stage IV could satisfy its design goal.

There was also a tendency to debate trivial points, such as which causal factors ought to be represented with which branch in Worksheet 4.

7.7 Chapter Summary

The design of the CAPM audit appears to be fundamentally sound. However, lessons from the trials revealed two areas as appropriate for further work:

a) Improve the audit support mechanism (i.e. the workbook) by including more worked examples.

b) Establish a much more efficient method of enabling audit teams to draw inferences from highly extensive audit trails.

8. DISCUSSION

The main deliverable of this project is a workbook-based, Delphi type, CAPM audit which is designed to evaluate the performance of an operational system. The CAPM audit was designed to be sufficiently flexible to be applicable to a wide range of audit scenarios. The results from the trial runs and the development exercises indicated that the goal is attainable, although the development programmes were necessarily restricted. The trials also failed to reveal any significant design flaws, measured against the project's terms of reference.

The audit was deliberately designed to enable a CAPM system be judged in terms of its impact on competitiveness. McFarlan[81], Porter and Millar[82] have proposed similar methodologies. To really appreciate its uniqueness, it is necessary to consider the fundamental paradigm behind the CAPM audit.

Firstly, the CAPM audit has been designed to help users to appreciate the linkage between the detail abstractions of CAPM systems (i.e. management modules, transaction processing modules and database) with competitive forces. By approaching the problem from this level of abstraction, it becomes much easier to translate the audit findings into further actions. In comparison, McFarlan's[81] methodology, for instance, deals with the linkage between information system and competitiveness only in very general terms. It is difficult, ultimately, to translate his audit results into meaningful actions. The generic CAPM framework proposed in this thesis also does not involve any reference to any particular management approach or technology. The auditor is thus encouraged to adopt a mindset that will not lead to pre-judgement of CAPM systems. No evidence could be found for the use of this approach in previous work.

Secondly, in a search for candidate methodologies, no equivalent methodologies were found within the production management domain. Many publications in production management deal with CAPM systems effectiveness and efficiency as a matter of 'good practice'. The CAPM audit approach presented here which correlates system with effectiveness, explicitly, is apparently unique.

Thirdly, the CAPM audit was not designed purely on the basis of production engineering. The design was based on fundamental principles drawn from a wide range of subject areas including computing, management and works on competitiveness (see chapters three and four). The resulting audit is thus capable of bridging the multi-disciplinary factors that are clearly characteristics of CAPM systems. This, in turn, helps to engender a more holistic appraisal of CAPM system performance. Many other candidate methodologies, that have been proposed tend to treat the issues of CAPM systems only from the perspective of a single discipline; for instance, to consider CAPM systems only as an operational research problem.

9. CONCLUSIONS

The objective of this work was to design and test an audit methodology to determine the effectiveness and efficiency of an installed CAPM system. The requirement was for a methodology which would facilitate a private audit and also cope with situations ranging from a partial (with restricted access to information) to a complete audit.

The initial task was to define the scope of the audit. It was considered that a valid and useful outcome was most likely to derive from a methodology which encouraged close co-operation between the audit beneficiaries (the client) and the auditor. It was further decided that the best approach was to view all CAPM systems as consisting of three basic types of modules: management modules, transaction processing modules and a database. This provided a framework within which the operation of any CAPM system could be studied and avoided reference to any confining technological or methodological constraints. This approach also enabled the CAPM system to be described in abstract terms, and resolved any problems which might have been caused by the pre-judgement of the value of any system. Finally, it was decided that the most valuable and useful measure of CAPM system efficiency and effectiveness was the system's impact on the user's competitiveness, which was defined in terms of a company's ability to contend with competitive forces.

To develop the audit, a sample of candidate methodologies drawn from appropriate theoretical frameworks and/or equivalent alternative methodologies were investigated. In all seven possible approaches were investigated. These alternative methodologies fall into seven broad categories; software engineering techniques (i.e. SADT), mathematical analysis of effectiveness and efficiency (i.e. operational research), Delphi-type techniques (i.e. structured debate), financial based analysis (i.e. cost-benefits), benchmarking against 'good practice', qualitative optimisation (i.e. prescribing a CAPM system against an appropriate context) and comparative studies (i.e. ratio analysis). These approaches were found to be unsuitable in the context of validity and practicality. The main concern is that many of these methodologies tended to require the auditor to obtain information that their audit scenarios were not, for valid reasons, likely to have. For instance, some existing methodologies require the auditor to supply precise numerical measures such as the amount of paper generated by the CAPM system. It is usually impractical for any company to maintain such measures, even if the information was valuable for auditing purposes.

From the investigation of alternative approaches, it was noted that an appropriate methodology which would have wide applicability could be derived from a Delphi approach. This technique promoted flexibility in the audit which was valuable in that it permitted a range of companies and activities to be studied. The approach also encourages a collaborative effort in auditing thereby permitting a wide range of data, experience and views to be obtained. The audit also draws upon a generic model of a CAPM system which was proposed to enable any CAPM system to be described without reference to any particular technology, management mode or control system.

A workbook based CAPM audit has been developed which is structured into four key stages:

a) Stage I which is designed to help an auditor establish the context in which an installed CAPM system operates.

b) Stage II which is designed to help an auditor appreciate the structure and scope of the installed CAPM system.

c) Stage III which is designed to help an auditor quantify the contributions to competitiveness made by an installed CAPM system.

d) Stage IV which is designed to help an auditor derive logical conclusions about the installed CAPM system performance.

The CAPM audit developed was tested in a series of trial runs. The scenarios chosen for the trials were meant to be representative of worst cases and intended, primarily, to be a test of the audit's ability to cope with a wide range of problems. Lessons from the trials, which it was found impossible to make entirely independent, revealed that the proposed framework itself was satisfactory, and that valuable results relating to the appropriate behaviour of the installed CAPM system could be obtained. The trial runs did indicate that there is scope for further improvements to be made, especially in Stage IV. These are briefly discussed in the chapter on further work.

10. FURTHER WORK

The design of the CAPM audit appears to be fundamentally sound. However, lessons from the trials revealed two areas as appropriate for further work:

a) Improve the audit support mechanism (i.e. the workbook) by including more worked examples.

b) Establish a much more efficient method of enabling an audit team to draw inferences from a highly extensive audit trails.

These problems areas could possibly be resolved by the use of computerised technologies, such as on-line help systems, laptop computers and automated document management systems. Therefore, future work will concentrate on designing computer-based support mechanisms.

FIGURES

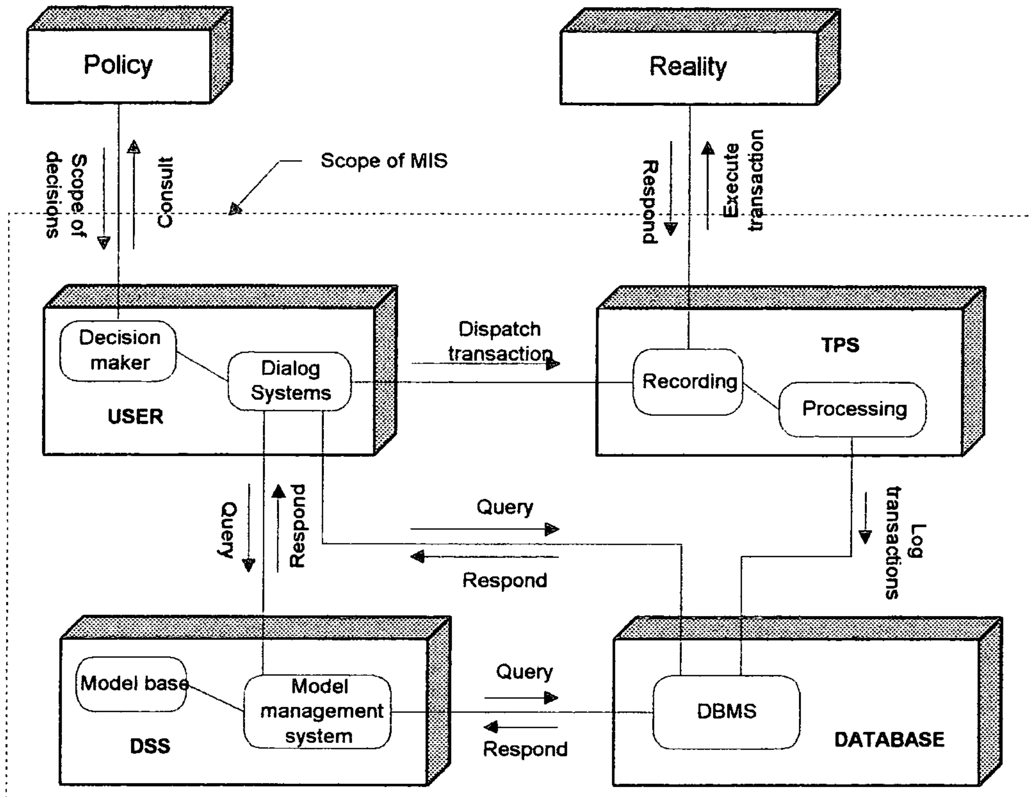

Figure 1 - Key Components of an MIS

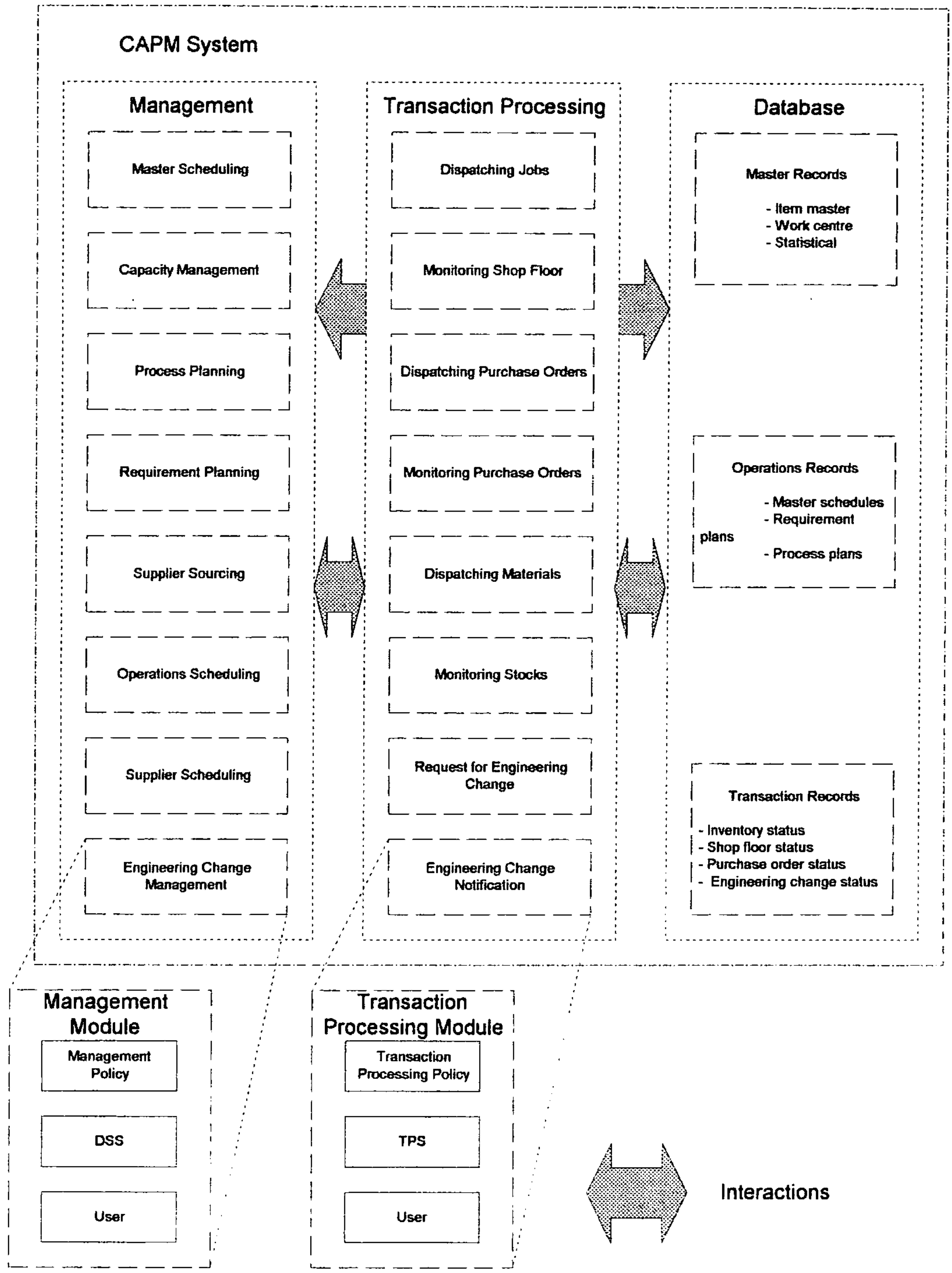

Figure 2 - A Generic CAPM Framework

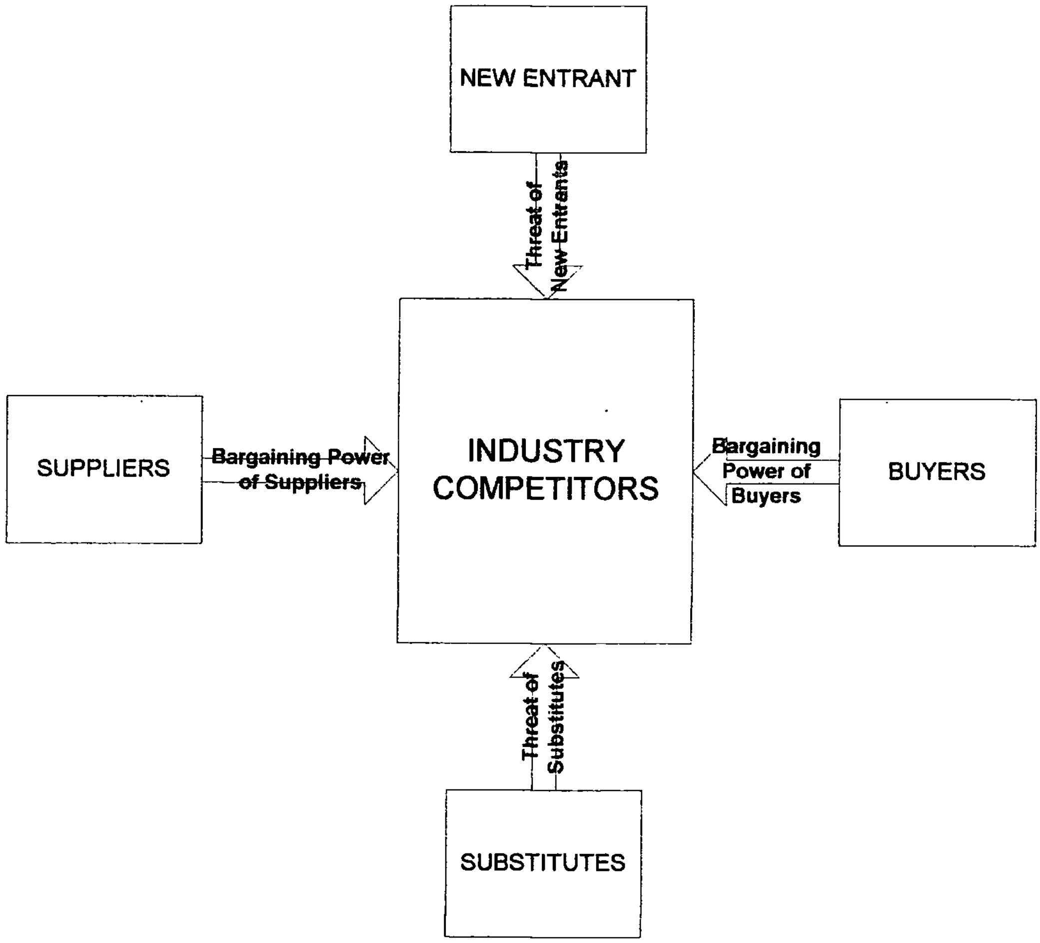

Figure 3 - Porter's Competitive Forces

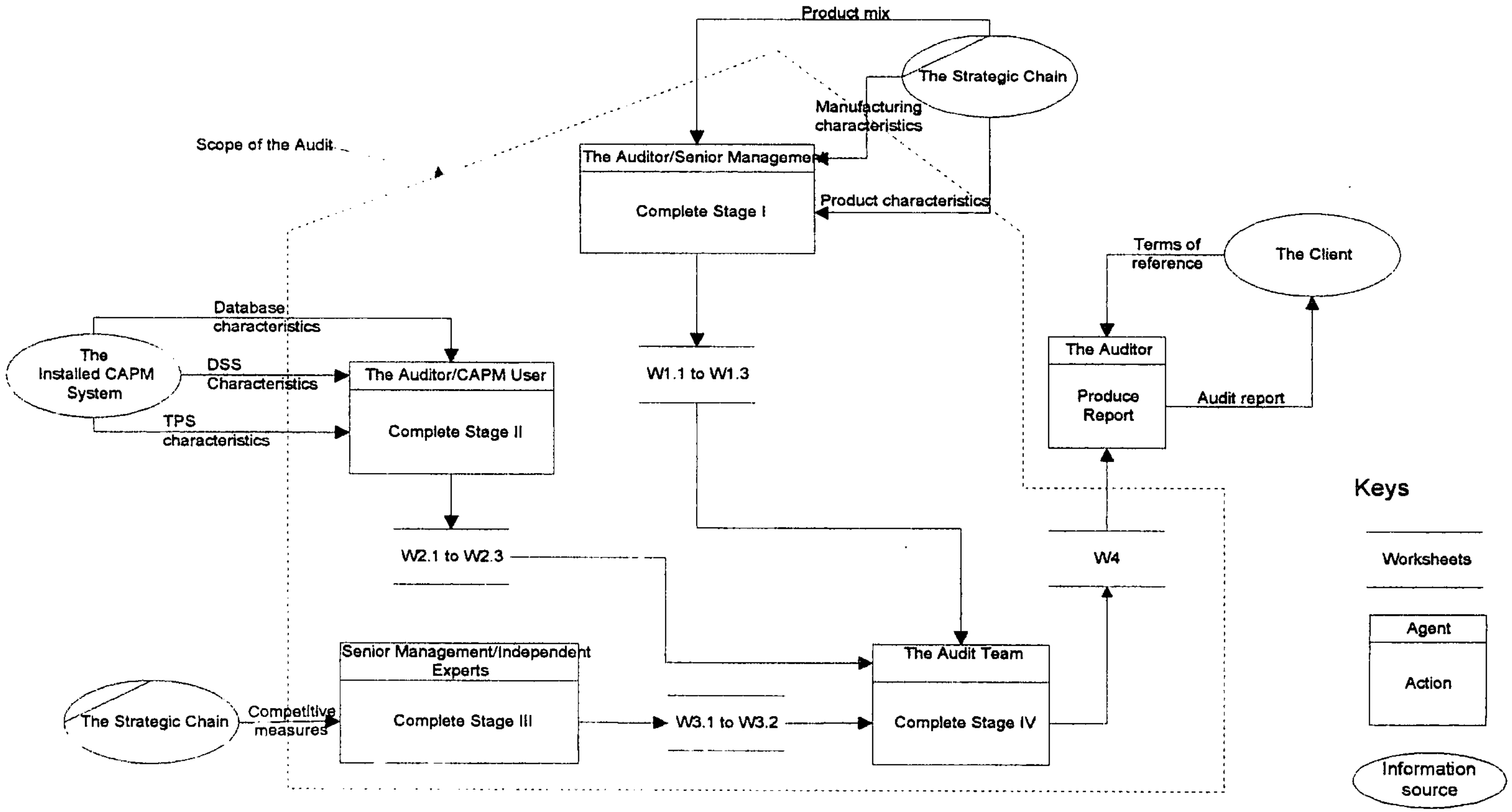

Figure 4 - A Functional View of the Audit

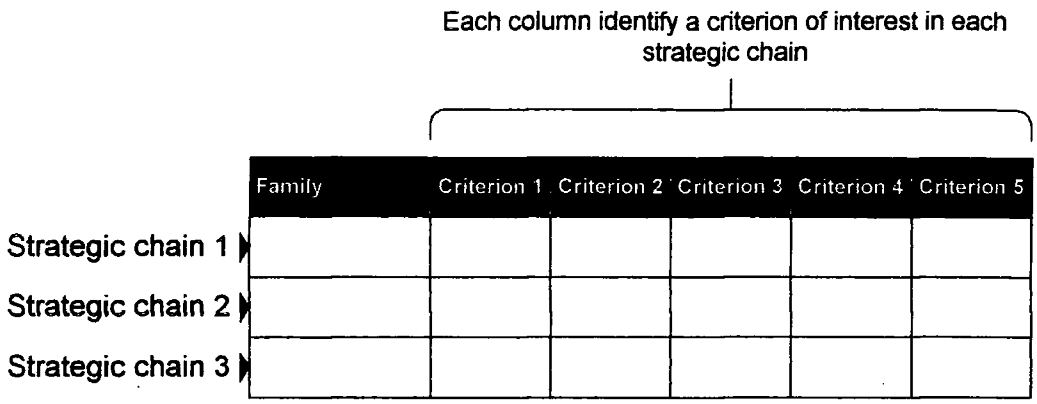

Figure 5 - Structure of Worksheets 1.1, 1.2 & 1.3

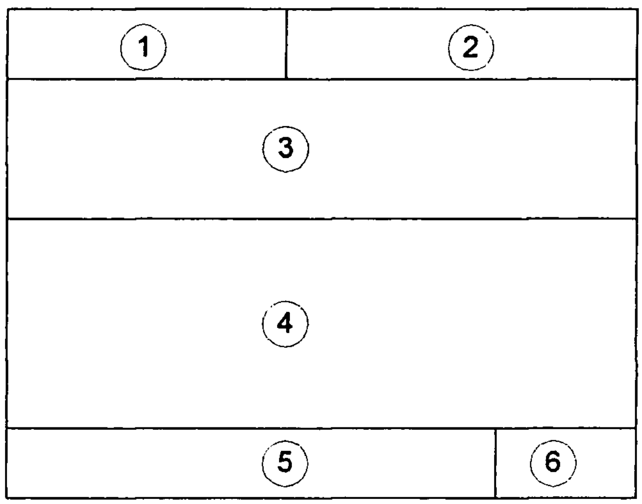

Figure 6 - Structure of Worksheet 2.1

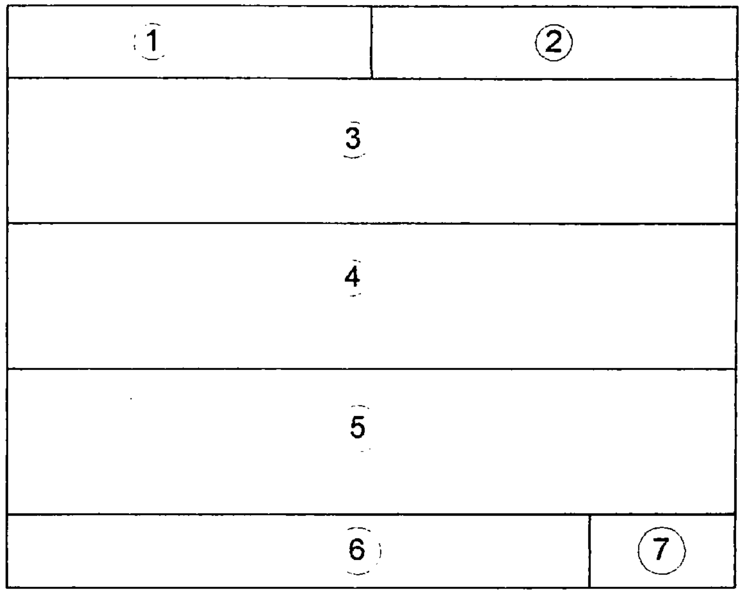

Figure 7 - Structure of Worksheet 2.2

1		User 1	User 2	User 3	User 4	User 5
Record 1	Jpdate Interval	2				
	Accessibility	3				
	Medium	4				
Record 2	Update Interval					
	Accessibility					
	Medium					
Record 3	Update Interval					
	Accessibility					
	Medium					

The "User" heading spans the columns User 1 to User 5.

The number of colums varies according to the audit scenario

Figure 8 - Structure of Worksheet 2.3.

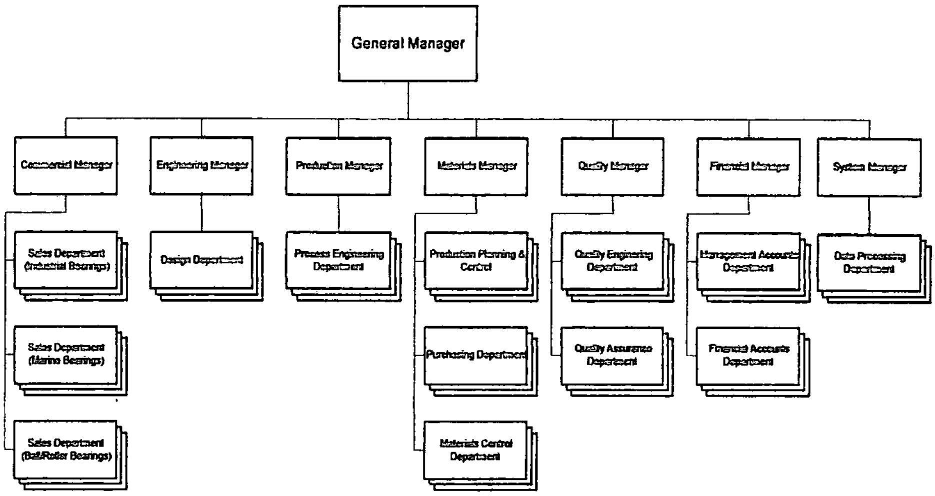

Figure 9 - Management Structure of Client A

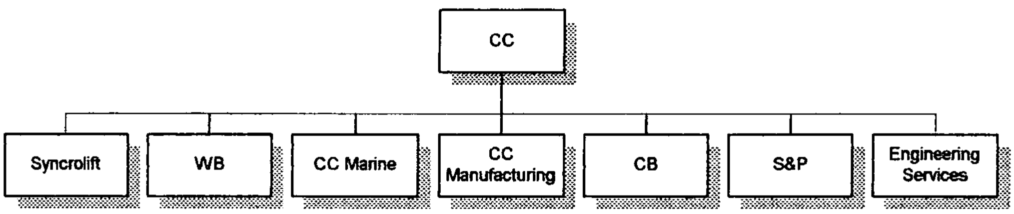

Figure 10 - Organisational Structure of Client B

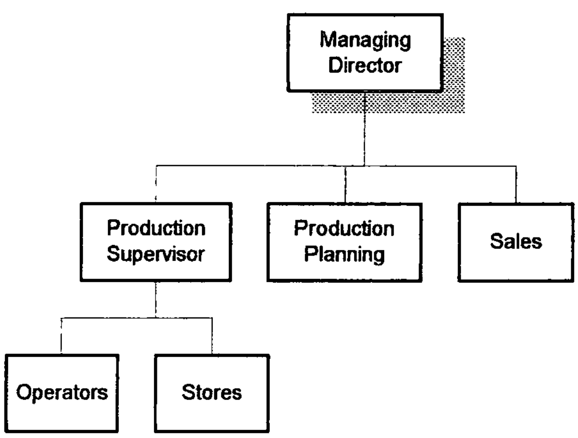

Figure 11 Management Structure of Client C

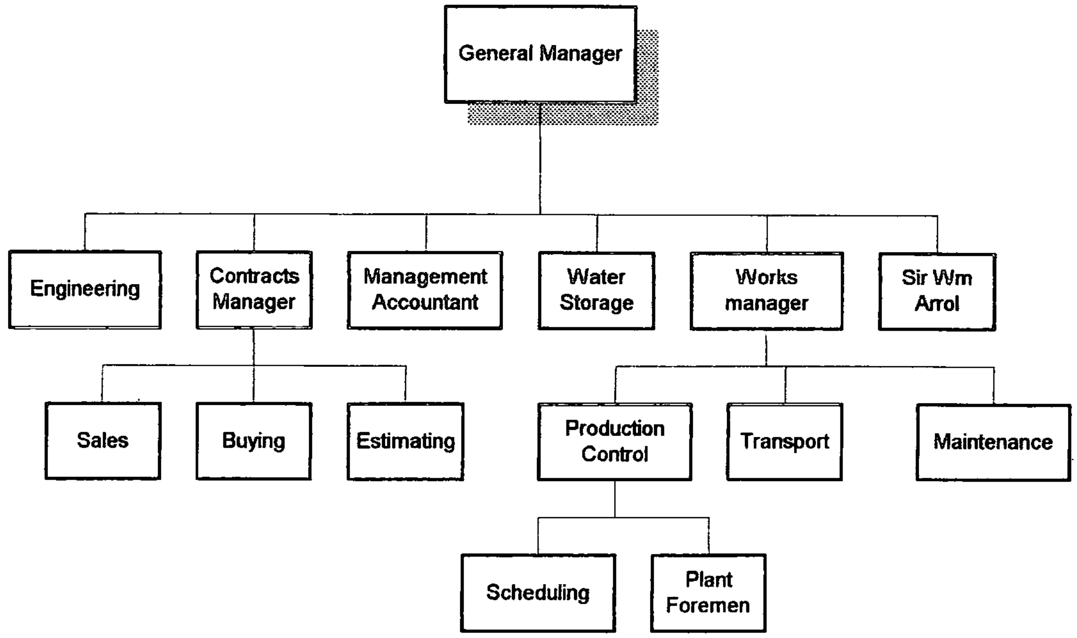

Figure 12 Management Structure of Client D

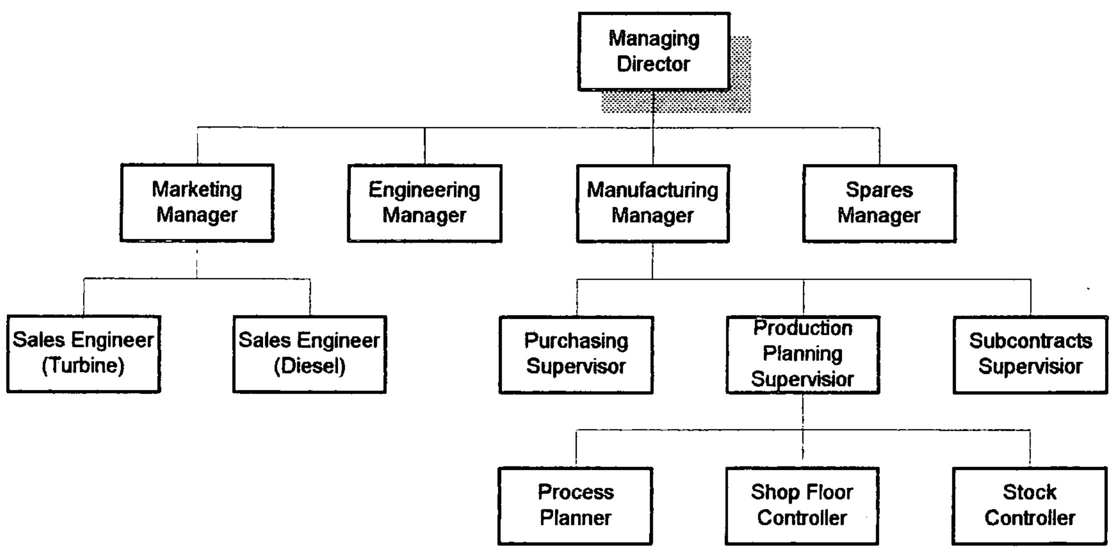

Figure 13 Management Structure of Client E

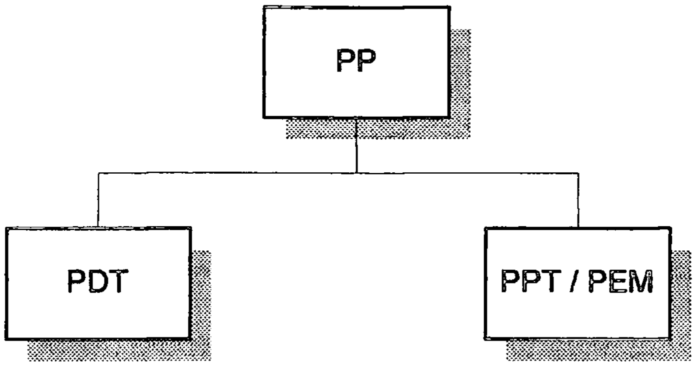

Figure 14 - Organisational Structure of Client F

TABLES

Required feature	Category I	II	III	IV	V	VI	VII
Is the methodology flexible enough to cope with the problems in a partial audit scenario?	+	-	+	0	-	-	0
Does the methodology engage the client in the audit?	+	-	+	-	-	-	-
Does it support the concept of competitiveness as the basis for CAPM effectiveness and efficiency?	+	0	0	-	-	-	-
Does the methodology address the problem of CAPM systems at an appropriate level abstraction?	-	+	0	0	-	-	-

Keys:
+ adopting this methodology would have positive influence on required feature
- adopting this methodology would have negative influence on the required feature
0 unsure of influence.

Table 1 - Summary of the Strength and Weaknesses of Candidate Methodologies

	Client					
Management Policy	A	B	C	D	E	F
Master scheduling	No formal policy	No formal policy	No formal policy	No formal policy	No formal policy	No formal policy
Capacity management	Semi formal policy	Semi formal policy	No formal policy	Semi formal policy	Semi formal policy	Semi formal policy
Process planning	No formal policy	No formal policy	No formal policy	No formal policy	No formal policy	No formal policy
Requirements planning	Semi formal policy	Semi formal policy	No formal policy	Semi formal policy	Semi formal policy	Semi formal policy
Supplier sourcing	Semi formal policy	No formal policy	No formal policy	No formal policy	Semi formal policy	No formal policy
Operations scheduling	No formal policy	No formal policy	No formal policy	Semi formal policy	Semi formal policy	No formal policy
Vendor scheduling	No formal policy	No formal policy	No formal policy	No formal policy	No formal policy	No formal policy
Engineering change management	No formal policy	No formal policy	No formal policy	Semi formal policy	Formal policy	Formal policy

Keys:
Formal policy   clearly written or inculcated
Semi formal policy   Very broad policy statements
No formal policy   Left entirely to the discretion of the decision makers.

Table 2 - An Overview of the Management Policies of the companies used in the development of the audit.

Client	Order Winning Criteria						
	Quality of Design	Quality of Conformance	Delivery Lead-time	Delivery Reliability	Flexibility of Volume	Flexibility of Design	Price
A	2	1	2	1	0	3	2
B	2	1	2	1	0	3	2
C	0	0	1	0	0	3	2
D	1	1	2	1	0	3	2
E	2	1	2	1	0	3	2
F	1	1	2	1	0	3	2

Keys:
3 Exact measures available
2 Measures available but require significant re-working of existing measures
1 Surrogate measures needed
0 Not available.

Table 3 - Availability of Measures for Order Winning Criteria

	Manufacturing Liabilities					
Client	Supplier Reliability	Supplier Availability	Utilisation of bottleneck resources	Availability of non-bottleneck resources	Inventory turnover	Lead time
A	1	0	1	0	3	3
B	1	0	1	0	2	3
C	0	0	1	0	2	3
D	1	0	1	0	2	3
E	1	0	1	0	3	3
F	1	0	1	0	2	3

Keys:
3 Exact measures available
2 Measures available but require significant re-working of existing measures
1 Surrogate measures needed
0 Not available.

Table 4 - Availability of Measures for Manufacturing Liabilities

Types of expertise			
CAPM users grade	Management grade	Independent grade	Total
9	6	3	18

Keys:
CAPM user grades - individuals directly responsible for the operations of the CAPM system (i.e. shop floor supervisors, master schedulers)
Management grades - senior managers such as Works Manager, General Managers, etc.
Independent experts - individual responsible for research in production management or MIS (i.e. academics or consultants).

Table 5 - Composition of Survey Respondents

Respond category	Factor A	Factor B	Factor C
Strongly agree	1%	4%	30%
Disagree	7%	20%	27%
Neutral	30%	40%	30%
Agree	52%	36%	33%
Strongly agree	10%	0%	0%

Table 6 - Result of Survey

APPENDIX A - Survey Questionnaire

You are required to register the extent of your agreement with the following statements.

Factor A

Having applied the CAPM audit, I am better informed my of my company's competitive position.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree

Factor B

Having applied the CAPM audit, I am better informed of the characteristics of my CAPM system.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree

Factor C

Having applied the CAPM audit, I am better informed of the relationship between my CAPM system and my company's competitive position.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree

REFERENCES

1 A.T. Kearney
Extract
The Professional Engineer. December 1990.

2 Feeny D., Earl M., and Ewards B.
Information System (IS) Arrangement to Suit Complex Organisation: An Effective IS Structure.
Discussion Paper. Oxford Institute of Information Management. Templeton College. 1989.

3 Marchi L.
Managing Inventory Control System Development
2nd International Symposium on Inventories. Budapest. August. 1982.

4 Seward H.
Evaluating Information Systems.
Part of an article in the Information systems Handbook edited by McFarlan F.W. & Norlan R.L. Dow Jones-Irwin Inc. 1975.

5 ICA
Auditing Standards and Guidelines.
Statement of Auditing, 'U' section of members handbook. Statement of Standard Accounting Practice (SSAP). Institute of Chartered Accountants of England and Wales. London 1980.

6 Institute of Internal Auditors.
Statement of the Responsibilities of the Internal Auditor.
(3rd Edition). 1971.

7 Howard L.R.
Principles of Auditing.
MacDonald and Evans Limited. 1981.

8 Burbidge J.L.
Production Planning and Control: Personal Philosophy.
Proceedings of IFIP WG 5.7 Working Conference on Decentralised Production Management Systems. Munich. Germany. March 1985.

9 Carlson E.D.
Evaluating the Impact of Information Systems.
Management Informatics. 3(2):57-67. 1974.

10 American Psychological Association.
Standards for Education and Psychological Test. Washington. American Psychological. 1974.

11 Bohrnstedt H.
Measurement.
Handbook of Survey Research edited by Rossi H.P., Wright J.D. and Anderson A.B. Academic Press. 69-121. 1983.

12 No Author.
Capital Spending.
Production. 38-45. 1988.

13 Feeny D., Earl M. and Ewards B.
Information System (IS) Arrangement to Suit Complex Organisation: An Effective IS Structure.
Discussion Paper. Oxford Institute of Information Management. Templeton College. 1989.

14 Kenny G.K. and Dunk A.S.
The Utility of Performance Measures: Production Managers' Perceptions.

IEEE Transactions on Engineering Management. 36(1):47-50. 1979.

15 Hamilton S. and Chervany N.L.
Evaluating Information System Effectiveness - Part I: Comparing Evaluation Approaches.
MIS Quarterly. 5(3):55-69. 1981.

16 Plossl G.W.
Cost Accounting in Manufacturing: Dawn of a New Era.
Production Planning and Control. 1(1):61-68.1990.

17 Holden K., and Hall P.E.
Computerguide 9: Production Control.
N.C.C. Publications. Manchester. 1973.

18 Orlicky J.A.
Materials Requirement Planning.
IBM Systems Journal. Issue No. 1. 1973.

19 Monniot J.P., Rhodes D.J., Towil D.R., and Waterlow J.G.
A Study of Computer-Aided Production Management in UK Batch Manufacturing.
International Journal of Operations and Production Management. 10(9):1-27. 1990.

20 Hendry L.C., and Kingsman B.G.
Production Planning Systems and their Applicability to Make-To-Order Companies.
European Journal of Operational Research. 40(1):1-15. 1989.

21 Hoey J., Kilmatin B.R., and Leonard R.
MRP Systems for Make-To-Order Companies.
International Journal of Production Research. 24(2):387-400. 1986.

22 Aggarwal S.C., and Aggarwal S.
The Management of Manufacturing Operations: An Appraisal of Recent Developments.
International Journal of Operations and Production Management. 5(3). 1985.

23 Rhodes D.
Computer Aided Production Management.
International Handbook of Production and Operations Management. Edited by Ray Wild. Cassell Education Limited. 1989.

24 Chambers A.D. and Court J.M.
Computer Auditing.
Second Edition. Pitman. 1986.

25 Alter S.L.
Decision Support Systems: Current Practice and Continuing Challenges.
Addision-Wesley. 1980.

26 Gershwin S.B., Hildebrant R.R., Suri R., and Mitter S.K.
A Control Perspective on Recent Trends in Manufacturing Systems.
IEEE Control Systems Magazine. April. 1986.

27 Flapper S.D.P., Miltenburg G.J., and Wijngaard J.
Embeding JIT into MRP.
International Journal of Production research. 29(2):329-341. 1991.

28 Browne J., HarhenJ., and Shivan J.
Production Management Systems: A CIM Perspective.
Addison-Wesley. 1988.

29 Mintzberg H.
The Structuring of Organisations: A Synthesis of Research.
Prentice-Hall. 1979.

30 Boothroyd G., and Dewhurst P.
Design for Assembly: Choosing the Right Method.
Machine Design. 94-98. November. 1983.

31 Davis G.B., and Olson M.H.
Management Information Systems: Conceptual Foundations, Structure and Development.
McGraw-Hill. 1988.

32 Smith S.B.
Computer Based Production and Inventory Control.
Prentice-Hall. 1989.

33 Wild R.
Production and Operations Management.
Cassell. 1986.

34 Vollmann T.E., Berry W.L., and Whybark D.C.
Manufacturing Planning and Control Systems.
Dave Jones/Irwin. 1984.

35 Anderson A.D., and Ostrenga M.R.
MRP II and Cost Management: A Match Made in Theory.
CIM Review. Summer 24-28. 1987.

36 Braiden P.M.
Manufacturing Control Systems Selection.
Internal Report. Department of Mechanical, Materials and Manufacturing Engineering. The University of Newcastle upon Tyne. Undated.

37 Hampton W.J. and Cook D.
Detroit Raises the Ante for Parts Suppliers.
Business Week. October 14, 1985.

38 Moden Y.
Smooth Production Lets Toyota Adapt to Demand Changes and Reduce Inventory.
Industrial Engineering. 13(8):42-51. 1981.

39 McManus J.J.
Control in the OPT Environment.
Production Engineer. July/August. 1987.

40 Goldratt E.M.
Computerised Shop Floor Scheduling.
International Journal of Production research. 26(3):443-445. 1998.

41 Swann D.
Using MRP for Optimised Schedules (Emulating OPT).
Production and Inventory Management. 27(2):30-37. 1986.

42 Simon H.A.
The New Science of Management Decisions.
Harpers and Brothers. New York. 1960.

43 Pounds W.
The Process of Problem Findings.
Sloan Management Review. 1(2):1-19. 1969.

44 Ewards W.
The Theory of Decision Making.
Psychological Review. 51(1):380-417. 1954.

45 ISO
STEP Part 1: Overview and Fundamental Principles.
Working paper. ISO TC184/SC4/. ISO-10303-1. 1992.

46 Porter M.E.
How Competitive Forces Shape Strategy.
Harvard Business Review. 57(2):137-145. 1979.

47 Woodward J.
Industrial Organisation: Theory and Practice.
Oxford University Press. Oxford. 1965.

48 Marucheck A.S. and McCelland M.K.
Strategic Issues in Make-To-Order Manufacturing.
Production and Inventory Management. 27(2):82-95. 1986.

49 Ansoff H.I.
Concept of Strategy.
Corporate Strategy. McGraw-Hill. 1965.

50 Gilbert X. and Strebel P.
The Handbook of Business Strategy: 1986-1987 Year Book.
William D. Guth (ed). Warrwer, Gorhan and Lamont. 1986.

51 Hill T.
Manufacturing Strategy: The Strategic Management of Manufacturing Functions.
MacMillan. 1985.

52 Garvin D.A.
Competing on the Eight Dimensions of Quality.
Harvard Business Review. Nov-Dec. 101-109. 1987.

53 Howell R.A. and Soucy S.R.
Operating Controls in the new Manufacturing Enviroment.
Management Accounting. 69(4):25-31. 1987.

54 Goldratt E., and Cox. J.
The Goal.
Gower Publishing Group. 1986.

55 Frizelle G.
CAPM Implementation Workbook.
IFS Publications. U.K. 1991.

56 Platts K.W. and Gregory M.J.
Manufacturing Audit in the Process of Strategy Formulation.
International Journal of Operations and Production Management. 10(9):1-27. 1990.

57 Rowan T.G. and Chatterton A.N.
Production System Audit.
The Production Engineer. 53(2):71-77. 1974.

58 Chandler J.S.
A Multiple Criteria Approach for Evaluating Information Systems.
MIS Quarterly. 6(1):61-74. 1982.

59 Bard J.F.
A Multi-Objective Methodology for Selecting Subsystem Automation.
Management Science. 32(12):1628-1641. 1986.

60 Hicks C., Braiden P.M. and Simmons J.E.L.
GR/E/23319 - CAPM Applications in Selected NEI Companies.
A Report of SERC/ACME. June. 1991.

61 Ridgeway K.
The GRAI Method of Decision Making.
Professional Engineer. January. 1990.

62 Bravoco R.R. and Yadav S.B.
A Methodology to Model the Functional Structure of an Organisation.
Computers in Industry. 6. 345-361. 1985.

63 Coad P. and Yourdon E.
Object-Oriented Analysis.
Prentice-Hall. 1990.

64 Buker D.W.
Performance Measurement.
American Production and Inventory Control Society. Conference Proceedings. 157-160. 1980.

65 Wright O.
MRP II: Unlocking America's Productivity Potential.
Oliver Wright Limited Publications. 1981.

66 Matlin G.
What is the Value of Investing in Information Systems.
MIS Quarterly. 3(3):25-34. 1981.

67 Cook M.E.
How to Evaluate Software Packages.
American Production and Inventory Control Society. Conference Proceedings. 1981.

68 Hansen J.V. and Hill N.C.
Control and Audit of Electronic Data Interchange.
MIS Quarterly. 13(4):403-412. 1989.

69 Miller G.J. and Dunn A.G.
Software Selection: One More Time!
American Production and Inventory Control Society. Conference Proceedings. 700-706. 1985.

70 Keen P.G.W.
Value Analysis: Justifying Decision Support Systems.
MIS Quarterly. 5(1):21-27. 1981.

71 Primrose P.L.
Selecting and Evaluating Cost-Effective MRP and MRP II.
International Journal of Operational Research. 10(1):51-66. 1989.

72 Grüwald H. and Van Der Linden P.M.J.
On the Choice of a Production Control System.
International Journal of Production Research. 18(2):273-279. 1980.

73 Barber K.D. and Hollier R.H.
The Use of Numerical Analysis to Classify Companies According to Production Control Complexity.
International Journal of Production Research. 24(1):203-222. 1986.

74 Boaden J.R. and Dale B.
Justification of Computer-Integrated Manufacturing: Some Insights into the Practice.
IEEE Transactions on Engineering. 37(4):291-296. 1990.

75 McGarrie B. and Kochhar A.K.
A Reference Model for the Selection of Manufacturing Control Systems Suitable for a Given Environment.
Working Paper. Manufacturing Systems Engineering Research Group. Department of Mechanical and Manufacturing Engineering. University of Bradford. 1990.

76 Date C.J.
An Introduction to Database Systems.
Addison-Wesley. 1990.

77 Torgerson W.S.
Theory and Methods of Scaling.
University of Chicago Press. 1958.

78 Guttman L.
Basis for Scalogram Analysis.
From Stouffer et al's Measurement and Prediction. Wiley Science Edition. 1966.

79 Osgood C.E., Suci G.J., and Tannenbaum P.H.
The Measurement of Meaning.
University of Illinois Press. 1966.

80 Ishikawa K.
What is Total Quality Control - The Japanese Way.
Prentice Hall. 1985.

81 McFarlan F.W.
Information Technology Changes the Way You Compete.
Harvard Business Review. 62(3):98-103. 1984.

82 Porter M.E. and Millar V.E.
How Information Gives You Competitive Advantage.
Harvard Business Review. 63(4):149-160. 1985.

VOLUME II

CAPM AUDIT:
A Methodology for the Evaluation of Installed CAPM System Effectiveness and Efficiency

Paul Jek Sitoh

Engineering Design Centre
University of Newcastle upon Tyne
Armstrong Building
Newcastle upon Tyne NE1 7RU
United Kindom
Tel: +44 (0191) 222 8777
Fax: +44 (0191) 261 6059
E-mail: p.j.sitoh@ncl.ac.uk

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Preface

The ability to audit your Computer Aided Production Management (CAPM) system is the first step in ensuring that your system is used effectively and efficiently.

The CAPM audit, as described in this book, is designed to help you to evaluate the your installed CAPM system in a formal and structured fashion. The CAPM audit will show you how to:

- identify the contribution of your CAPM system to your company's competitive position(s);
- discover the capabilities of your CAPM system.

How to Use this Book

This book is designed to:

- help you evaluate your CAPM system in a structured manner;
- function as a audit trail to as you evaluate your CAPM system.

This audit, it has to be emphasised, is not intended for an individual effort; the audit requires team effort. Neither should you see this audit as a means to detect fraud. You should see this audit as a way of enabling you and your staff member to joinly work to analyse your CAPM system.

There are three stages in the evaluation of a CAPM System:

- **Pre-audit stage: Assemblying the audit team.** The task in this stage is organise your audit team by identifying and delegating each team member according to their appropriate roles.
- **Stage One: Establishing the context in which your CAPM system is operating.** The task here is to identify the characteristics of the strategic chains in your company. Each strategic chain refers to all of the activities necessary to deliver a product or service that meets the expectation of the market.
- **Stage Two: Analysing your CAPM system infrastructure.** The task here is to decompose your CAPM system into appropriate modules and, to note their role (what are they intended for) and their functionality (how they fulfil their role).
- **Stage Three: Performance Analysis.** The task here is to obtain measures related to the degree of competitiveness of each of your company's strategic chain; and by implications the contribution offered by your CAPM system.
- **Stage Four: Identfiying the problems associated with your CAPM system.** The task here is to assemble the your information from the preceeding pages, with the help of your audit team, to derive conclusion(s) relating to your CAPM system.

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APPENDIX A 55

Assemblying the Audit Team

An individual shall be appointed for the role of the auditor. This person should ideally be knowlegeable in both Management Information Systems (MIS) and production management paradigm (such as MRP/MRP II, OPT or JIT). The auditor's role is solely to organisation the team, the proceeedings of the evaluation and the collation of information.

A complete audit team should comprise of three key groups of individuals:

- Group I - The company's management team. For this group, get participations of senior managers from each of the following the departments - Marketing, Materials Management and Manufacturing.

- Group II - The user of the CAPM system. For this group, get participation of individuals involve in buying, scheduling, shop floor activities and inventory control.

- Group III - Independent experts. This group of people should ideally be from outside your company; for instance, this group could be represented by external consultants or relevent academics.

Whilst the audit requires team effort, it is not necessary for the entire team members to be present all the time. The tasks should be delegated accordingly:

- Members of Group I are needed in Stage Two, Stage Four and Stage Five

- Members of Group II are needed in Stage Three and Stage Five.

- Members of Group III are needed in Stage Four and Stage Five.

Worked Example

Scenario. The company is subdivided to two manufacturing units (to be known as Unit A and Unit B). The two units are managed by the same senior management team, which compose of a general manager, marketing manager, engineering manager, production manager and financial manager. At production control level, only some departments are shared, others are distributed. The nature of the distributions is summerised in Table 1. The table indicates that sales, data processing and process planning departments are responsible for the two units. Each unit main their own production planning, shop floor, design and purchasing departments.

The company's CAPM architecture is shown in Figure 1.

The assembled audit team. Based on the scenario described previously, the senior management component of the audit team shall include these agents:

- The marketing manager who is expected to provide the expertise necessary to complete worksheet 1.1 and the whole of stage IV.

- The production manager who is expected provide the expertise necessary to complete worksheet 1.2, worksheet 1.3 and the whole of stage IV.

- The financial manager is expected to provide expertise necessary to complete stages III and IV.

The CAPM user component of the audit team shall composed of representatives from these;

- sales department;
- data processing department;
- production planning departments (one from each unit);
- stores departments (one from each unit);
- shop floor department (one from each unit);
- processing planning department;
- purchasing departments (one from each unit).

	User Designation		
Department	Unit A		Unit B
Sales		1	
Data processing		2	
Production planning	A3		B3
Stores	A4		B4
Shop floor	A5		B5
Process Planning		6	
Purchasing	A7		B7
Senior Management		8	

Table 1 - CAPM user designation

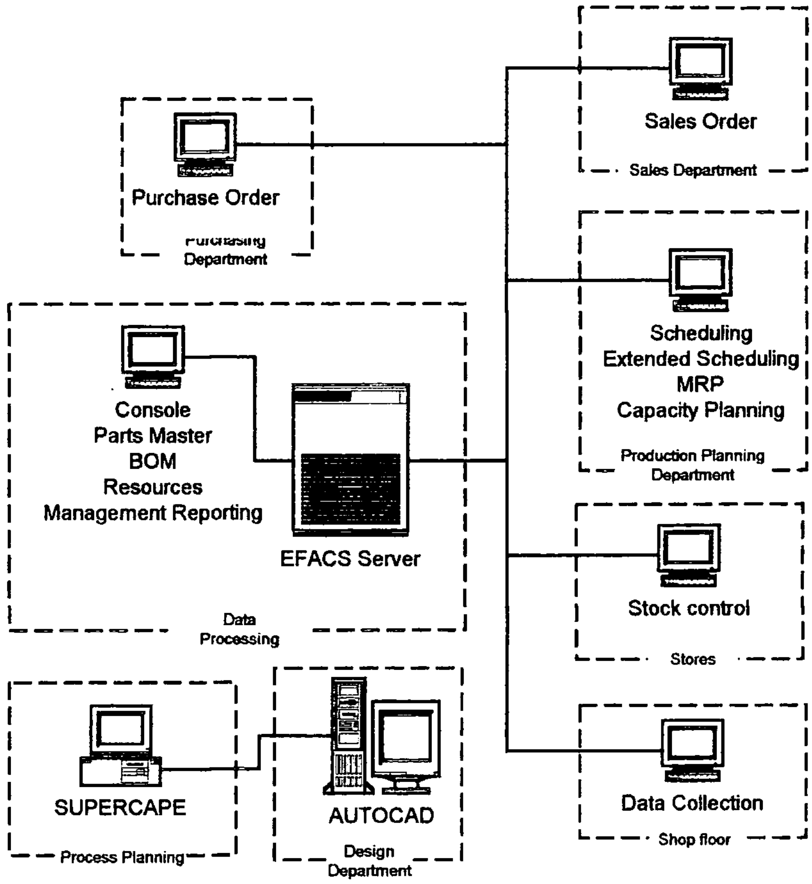


Figure 1 - The CAPM Architecture

STAGE I - Establishing the Context in Which the CAPM System is Operating

In this stage, the task of the audit team is to classify the company into strategic chains and then analyse each chain. A strategic chain is defined as the activities necessary to deliver a product that meets the expectation of the martket.

The rationale behind this approach are as follows.

- The competitiveness of a company is not determined by a complete organisation jostling for advantage in a market place. A company, in fact, occupies several competitvie position, depending on the range of products or services that the company offer. Each product or service type (i.e. strategic chain) usually occupies a particular market segment. For instance, a company manufacturing computers may have product ranging from mainframes to PCs; the market for mainframe is typically concern with performance-features sensitive whereas the market for PC is primarily price-performance sensitive.

- To help concerntrate the minds of the audit team to the fact that the effectiveness and efficiency of any CAPM system is a function of its impact on a company's competitiveness. After all, the survival of a company is not going to be dictated by how well a CAPM system is functioning but whether it is doing the right thing.

Completing Worksheet 1.1

Procedure

Step 1. List each product family down on the left-hand column. A product family is a grouping of products:

- that compete within the market-place in identical ways;

- having broadly similar value-added characteristics.

Step 2. For each family, supply appropriate information for each of the criteria listed in the commentary.

Commentary

The criteria listed in the worksheet are as follows:

(a) **Sales revenue**. Supply the percentage of total sale revenue attributed to the family.

(b) **Contribution margin**. Supply the percentage of total contribution attributed to the family. Contribution is the earnings before interest and taxes.

(c) **Growth potential**. Indicate if the family is in the *market entry phase, rapid growth phase, maturity phase* or *decline phase*.

(d) **Market share**. Accurate data in terms of percentage share is preferred. Otherwise simple ranking will suffice.

(e) **Competitors**. Indicate alternative products.

The information for criteria (a) and (b) is intended to provide indication of the relative value of each family. The information for citeria (c), (d) and (e) is intended as indication of the kind of competitive strategy appropriate to each chain.

Completing Worksheet 1.2

Procedure

As for worksheet 1.1.

Commentary

The criteria listed in the worksheet are as follows:

(a) **Product position**. Indicate the point at which the customer initiated his or her orders. The key positions are *Engineer-To-Order* (ETO), *Unique Make-To-Order* (UMTO), *Repeat Make-To-Order* (RMTO), *Assemble-To-Order* (ATO) and *Make-To-Stock* (MTS).

(b) **Product structure**. Calculate the number of levels from a representative engineering BOM. Generally speaking, the product structure equates to the number of assembly stages involved in the manufacture of the product. There may be instances where so-called phantom items are incorporated in a BOM. These phantom items are incorporated in a BOM to reflect intermediate production stages (i.e. partly machined item) and they constitute a level in a product structure. For this audit do not count the level occupied by the phantom level.

(c) **Number of components**. The criteria applies to the number of components per product. Only a rough estimate is needed.

(d) **Bought-out item (%)**. The percentage of bought-out items.

These criteria are intended as indication of the uncertainties likely to impact the client's production activities.

Completing Worksheet 1.3

Procedure

Same as worksheet 1.1.

Commentary

The criteria listed in the worksheet are as follows:

(a) **Business unit**. Companies are not necessarily organised into a monolithic entity. A non-monolithic company is usually organised into business units. A business unit, in this case, refers to an independent manufacturing facility. For this criterion, supply the name of the unit. This criterion is intended to provide an indication of the scope the clients' CAPM system.

(b) **Manufacturing capability**. Indicate the manufacturing content of design activity (i.e. percent of labour hours), assembly activity (percent of distinct in-house assembly), machining activity (percent of distinct components made in-house from raw materials) and inspection (percent of components inspected in-house). This criterion is to provide an indication of the manufacturing characteristics of each family.

These criteria are intended as indication of the scope of the client's CAPM system influence.

Worked Example

Scenario. The audit team has identified four product families, namely:

(a) General mountain bicycles;

(b) Professional mountain bicycles;

(c) Alpha series;

(d) Omega series.

The competitors to these families are Dragon bicycle, Speedy bicycle, and Raylay bicycle.

All products are made to stocks and their BOM structure is similar to the one shown in Figure 2.

The first two families in the list are manufactured in Unit A and the second two families are manufactured in Unit B.

80% of the bicycle components are designed in-house, 100% assembled in-house, 10% machined in-house, 100% inspected in-house.

Completed worksheets. Examples of the completed worksheets, based on the sceanrios described earlier, are illustrated in Figure 3, Figure 4 and Figure 5.

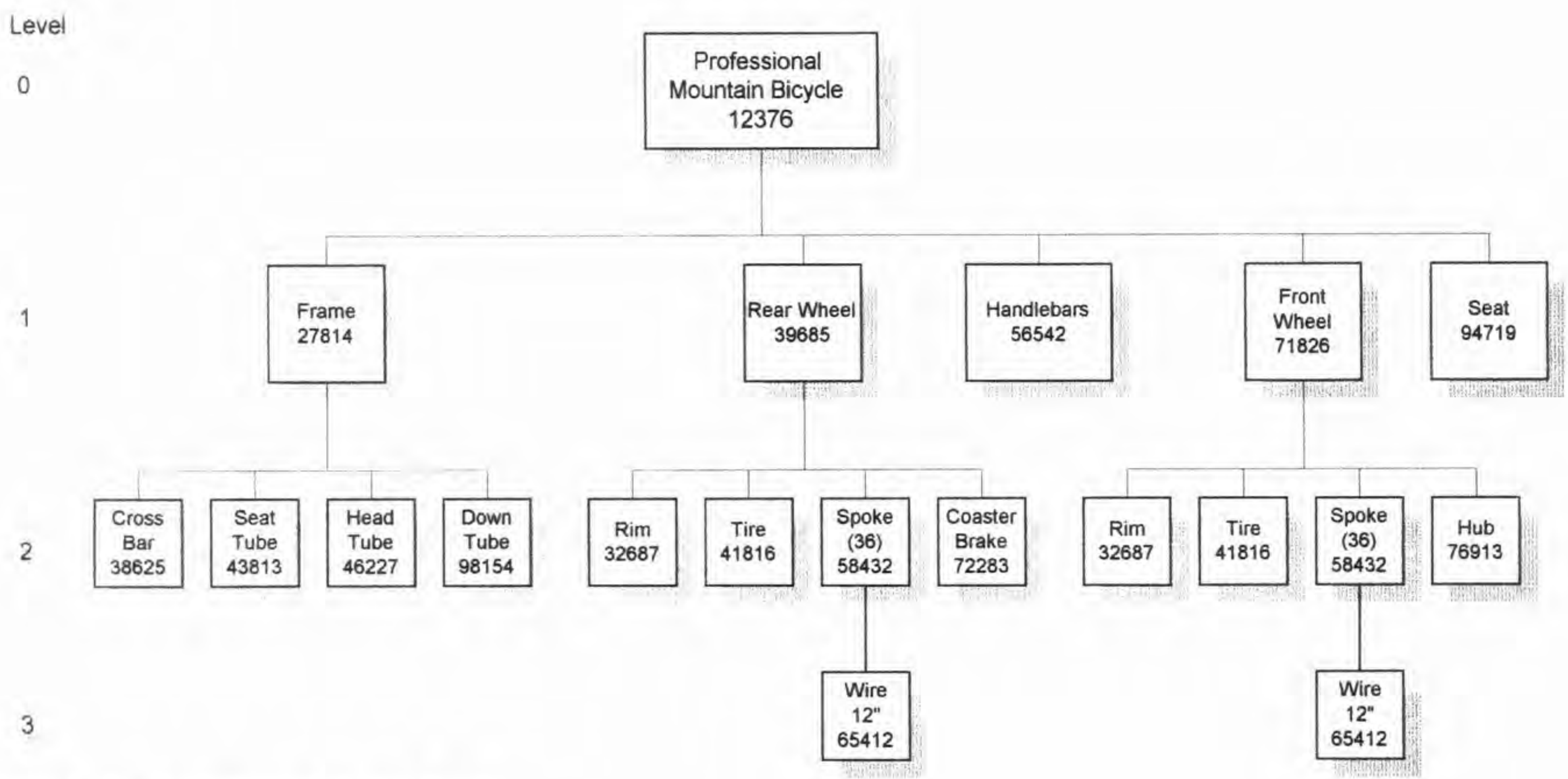


Figure 2 - BOM for Professional Mountain Bicycles.

Product Family	Sales Revenue (%)	Contribution Margin (%)	Growth Potential	Market Share	Competitors
Professional Mountain Bicycles	20%	10%	Mature	65%	Dragon bicycle, Speedy bicycle
General Mountain Bicycles	20%	50%	Rapid growth	25%	Speedy bicycle
Alpha Series	30%	30%	Mature	70%	Rayley bicycle
Omega Series	30%	10%	Mature	10%	Raylay bicycle

Figure 3 - A Completed Worksheet 1.1

Product Family	Product Position	Product structure	Number of components
Professional Mountain Bicycles	ETO	4	85
General Mountain Bicycles	UMTO	4	85
Alpha Series	RMTO	4	85
Omega Series	MTS	4	85

Figure 4 - A Completed Worksheet 1.2

		Manufacturing capability			
Product Family	Business unit	Design?	Assembly?	Machining?	Inspection?
Professional Mountain Bicycles	Unit A	80%	100%	10%	100%
General Mountain Bicycles	Unit A	80%	100%	10%	100%
Alpha Series	Unit B	80%	100%	10%	100%
Omega Series	Unit B	80%	100%	10%	100%

Figure 5 - A Completed Worksheet 1.3 (Based on Client B)

STAGE II - Evaluating the CAPM System

All CAPM systems, regardless of MRP/MRP II, JIT, OPT or even proprietary systems, will have the same underlying architecture. Simply put, the operational characteristics of a CAPM system is characterised by the variations in each of the following basic modules:

- Management modules;
- Transaction processing modules;
- Database modules.

Management modules. All CAPM systems will have eight distinct types of management modules dealing functional aspects of production management decisions such as inventory, capacity planning and engineering changes. The eight distinct types of modules also reflect a three level hierarchical ordering of management decisions, from long term, medium term to short term planning.

The characteristics of each management module varies according to: the management policy instituted, types of Decision Support System (DSS) afforded and the experties of the decision makers (i.e. Users). The task for the audit team is to analyse these key elements of a management module.

Transaction processing modules. A transaction is an activity like the transfer of materials. Transaction records are needed to direct, report on or confirm a transaction. Transaction processing modules are concerned with the production of transaction records.

All CAPM systems will have eight distict types of modules that correspond to the monitoring and dispatch of production orders, purchase orders, inventory control and engineering changes.

The characteristics of each module is varies according to the number of transaction records to be processed, transaction policy instituted, types of Transaction Process System (TPS) afforded and the experties of the human elements (i.e. Users). The task for the audit team is to analyse those elements of the module.

Database. The database of a CAPM system is a repository of information about the production management environment. All CAPM system database will have information classified into three basic record types; Master records, operational records and transaction records.

The characteristics of each record type varies according to its accessibility, its update frequencies and database technology (i.e. paper-based, flat-file or DBMS) afforded. The task for the audit team is to analyse those elements of the database.

Completing Worksheet 2.1

Procedure

Step 1. Consider each family in turn.

Step 2. Reproduce worksheet 2.1, making sure that the number of reproduction corresponds to these management modules:

(a) Master scheduling. This module covers production management functions concerned with the scheduling of end-items and final assemblies.

(b) Capacity management. This module covers matters concerned with medium term expansion and/or contraction of manufacturing capacity.

(c) Process planning. This module covers matters concern with the issues of plant layout and/or job routing.

(d) Requirements planning. This module covers matters concerned with the establishment of component and sub-assembly item schedule and material requirements.

(e) Supplier sourcing. This module covers matters concerned with medium term relationships between supplier and client.

(f) Operations scheduling. This module covers matters concerned with short term scheduling and sequencing of production orders.

(g) Vendor scheduling. This module covers matters concerned with short term scheduling and sequencing of purchased orders.

(h) Engineering change management. This module covers matters concerned with the scheduling of engineering change request.

Step 3. For each worksheet supply information for the criteria as listed in the commentary.

Commentary

The criteria listed in the worksheet are as follows:

(a) **Module**. Supply the name of policy module being investigated.

(b) **Family(ies) affected.** Indicate the family or families being investigated.

(c) **Managament Policy**. Describe the rules or guidelines that express the limits within which the policy module is allowed to operate.

(d) **DSS Characteristics**. (i) Supply the name of the software system used. (ii) Enumerate only the DSS features relevent to the modules being investigated. (iii) Describe the extent of functional integration by noting the users' accessibility to all DSS features. (iv) Indicate the flexibility of DSS. (v) Indicate the hardware used under the lable 'process power'.

(e) **User Characteristics**. Identify individual(s) responsible for the execution of policy module, and the level of technical support (e.g. User-guides, training) afforded.

(f) **User Designation**. Supply a label, such as serial number, to represent the users responsible for the policy module being investigated. It is possible that an individual could have responsiblities for more than one module. With a user designation, the auditor need not have to rewrite the same detail again.

Note for criterion (d), it is up to the auditor and domain experts to decide on what constitute relevent features.

The information for these criteria is intended to provide an indication of the characteristics of the policy module being investigated.

Completing Worksheet 2.2

Procedure

Step 1. Consider each family in turn.

Step 2. Reproduce worksheet 2.2, making sure that there is one for each of the following modules:

(a) Dispatching jobs. This module covers activities concern with the release of production orders to assigned workers and machines.

(b) Shop floor monitoring. This module covers activities concerned with the recording of production order status.

(c) Dispatching purchase orders. This module covers the activities concerned with the released of purchase orders to appropriate suppliers.

(d) Monitoring purchase orders. This module covers the activities concerned with the recording of purchase order status.

(e) Dispatching materials. This module covers the activities concerned with the release of materials, part or end-item inventories.

(f) Monitoring stocks. This module covers the activities concerned with the monitoring of bought-out, part or end-item inventories.

(g) Request for engineering change. This module covers the activities concerned with the requests for engineering change.

(h) Engineering change notification. This module covers the activities concerned with the release of notifications to effect engineering change.

Step 3. In each worksheet estimate number of transactions involved, describe the transaction processing policy, TPS and user characteristics.

Commentary

The criteria listed in the worksheets are as follows:

(a) **Number of Transactions**. Estimate the number of transactions to be processed by the TPS.

(b) **Transaction Processing Policy**. Describe how transactions are effected.

(c) **Transaction Processing System**. Identify the TPS afforded for the transaction processing.

(d) **User characteristics and designation.** Same approach as worksheet 2.1.

Completing Worksheet 2.3

Procedure

Step 1. Consider each family in turn.

Step 2. Each rows of the worksheet indicates a particular record to be investigated. For each row, describe the record's update interval, accessibility, and database characteristics.

Commentary

The criteria listed in this worksheet are as follows:

(a) **Update interval.** Indicate how often data are updated. For instance, daily, monthly or on exceptional basis (i.e. when required).

(b) **Accessibility.** Indicate if the record is linked on-line or off-line to the list of users identified in the policy and TPS modules.

(c) **Database Characteristics.** Indicate the medium on which the records are held in a paper-base system, file-oriented system or Database Managment System (DBMS) oriented system.

Worked Example

Scenario. The company uses a CAPM system with software modules described in Appendix A and Figure 1.

Completed worksheet. Examples of completed worksheets based on the scenario described previously are as follows.

Figure 6 shows a completed Worksheet 2.1 for master scheduling.

Figure 7 shows a completed worksheet 2.1 for capacity management.

Figure 8 shows a completed worksheet 2.1 for process planning.

Figure 9 shows a completed worksheet 2.1 for requirements planning.

Figure 10 shows a completed worksheet 2.1 for supplier sourcing.

Figure 11 shows a completed worksheet 2.1 for operations scheduling.

Figure 12 shows a completed worksheet 2.1 for supplier scheduling.

Figure 13 shows a completed worksheet 2.1 for engineering change management.

Interviews of CAPM users provides all of the information necessary for worksheet 2.2.

Figure 14 shows a completed worksheet 2.2 for dispatching jobs transactions.

Figure 15 shows a completed worksheet 2.2 for monitoring shop floor transactions

Figure 16 shows a completed worksheet 2.2 for dispatching purchase orders transactions.

Figure 17 shows a completed worksheet 2.2 for monitoring purchase orders transactions.

Figure 18 shows a completed worksheet 2.2 for dispatching materials transactions.

Figure 19 shows a completed worksheet 2.2 for monitoring stocks transactions.

Figure 20 shows a completed worksheet 2.2 for request for engineering change transactions.

Figure 21 shows a completed worksheet 2.2 for engineering change notification transactions.

Interviews of CAPM users provided the information necessary to complete worksheet 2.3.

Figure 22, Figure 23 and Figure 24 illustrate completed versions of worksheets 2.3a, 2.3b and 2.3c series.

Module: *Master scheduling*	**Family(ies) affected:** *All*
Management Policy: *End-item and final assembly items are scheduled on the basis of promised delivery date minus buffer period. The buffer is only an estimate based on the judgement of the policy maker (see User Section).*	
DSS Characteristics **Name of software:***EFACS* **Features:** *Backward and forward scheduling based on cost constraints or lead-time constraints.* **Functional integration:** *Fully integrated with other EFACS modules.* **Flexibility:** *Dependent on vendor support.* **Processing power:** *Mainframe*	
User Characteristics **Responsibilities:** *Production planning department.* **User support:** *No formal policy statement or formal training programme*	**User designation:** *A3, B3*

Figure 6 - A Completed Worksheet 2.1 (Master scheduling)

Module:*Capacity Management*	**Family(ies) affected:** *All*
Management Policy: *Capacity management via sub-contracting out. The decision on whether to subcontract out or otherwise, lies with the discretion of the decision maker (see user). The decision maker may but is not compel to consult reports of on capacity requirement. The reports reveal capacity requirement only on a departmental and monthly basis.*	
DSS Characteristics **Name of software:** *EFACS* **Features:** *Standard capacity planning techniques, such as RCCP and CRP.* **Functional integration:** *Fully integrated with other EFACS modules.* **Flexibility:** *Dependent on vendor support.* **Processing power:** *Mainframe*	
User Characteristics **Responsibilities:** *Production planning department.* **User support:** *No formal policy statement or formal training programme*	**User designation:** *A3, B3*

Figure 7 - A Completed Worksheet 2.1 (Capacity Management)

Module: *Process Planning*	Family(ies) affected: *All*

Management Policy:

Lead times are calculated from standard times (routings not considered).

DSS Characteristics

Name of software: *SuperCape.*

Features: *Algorithms to calculate lead-times based. Plus, a very limited optimisation algorithm for routings (i.e. system can workout best routings between two alternative resources based on cost and set-up constraints).*

Functional integration: *Localised system.*

Flexibility: *Software architecture is system specific.*

Processing power: *PC*

User Characteristics	User designation:
Responsibilities: *Production controller*	*6*
User support: *No formal statement of policy or formal training programme*	

Figure 8 - A Completed Worksheet 2.1 (Capacity Management)

Module: *Requirements planning*	Family(ies) affected: *All*

Management Policy:

The MRP approach is used to calculate requirements for stock items valued at more than 15% (only a guide-line) of the total value contract value. Bulk items are managed on a two-basis. The lead-times for MRP calculations are based on values provided by estimating department but can be adjusted by the decision maker (see user).

DSS Characteristics

Name of software: *EFACS.*

Features: *Standard MRP features. Additional features for backward and forward scheduling, and four alternative batching rules: multiple of re-order quantity, re-order quantity plus rounding, minimum quantity, quantity required (i.e. lot-for-lot).*

Functional integration: *Fully integrated with other EFACS modules.*

Flexibility: *Dependent on vendor support.*

Processing power: *Mainframe*

User Characteristics	User designation:
Responsibilities: *Production controller.*	*A3, B3*
User support: *No formal policy statement or formal training programme..*	

Figure 9 - A Completed Worksheet 2.1 (Requirements Planning)

Module: *Supplier Sourcing*	Family(ies) affected: *All*
Management Policy: *Multi-sourcing and supplier selected on the basis of competitive tender.*	
DSS Characteristics **Name of software:** *None* **Features:** *N.A.* **Functional integration:** *N.A.* **Flexibility:** *N.A.* **Processing power:** *N.A.*	
User Characteristics **Responsibilities:** *Purchasing department* **User support:** *No formal statement of policy.*	**User designation:** *A7, B7*

Figure 10 - A Completed Worksheet 2.1 (Supplier Sourcing)

Module: *Operations scheduling*	Family(ies) affected: *All*
Management Policy: *Operations schedule is left entirely to the discretion of the shop floor supervisor as long as it meets required due dates set in the requirements plans.*	
DSS Characteristics **Name of software:** *EFACS.* **Features:** *See master scheduling module* **Functional integration:** *Fully integrated with other EFACS module.* **Flexibility:** *Dependent on vendor support.* **Processing power:** *Mainframe*	
User Characteristics **Responsibilities:** *Shop floor* **User support:** *No formal policy statements or formal training programme.*	**User designation:** *A5, B5*

Figure 11 - A Completed Worksheet 2.1 (Operations Scheduling)

Module: *Supplier scheduling*	Family(ies) affected: *All*
Management Policy: *The purchase orders schedules are based on quoted delivery times from suppliers or negotiated prior to the release of the orders.*	
DSS Characteristics Name of software: *None.* Features: *N.A.* Functional integration: *N.A.* Flexibility: *N.A.* Processing power: *N.A.*	
User Characteristics Responsibilities: *Purchasing department* User support: *No formal policy statement or formal training programme.*	User designation: *A7, B7*

Figure 12 - A Completed Worksheet 2.1 (Supplier scheduling)

<table>
<tr><td><u>Module:</u> Engineering Change Management</td><td colspan="2"><u>Family(ies) affected:</u> All</td></tr>
<tr><td colspan="3"><u>Management Policy</u>
The acceptance of an Engineering Change is strictly controlled and subject to departmental approval and, where appropriate, authorisation by the General Manager.
Customer initiated change.
Subject to the approval of the contracts manager.
Changes are only acceptable on the customer's acceptance of the full commercial costs and of any resulting production delays to the full contract.
Engineering, Purchasing or Manufacturing initiated changes.
Subject to the approval of the Engineering Manager and, when the change is requested to alleviate production problems, the Works Manager.
Changes are only acceptable when they are technically and commercially desirable or could alleviate manufacturing problems without resulting in a substantial delay to the production programme. The quality and reliability of the product must not be compromised. (Judgement rest with the relevant authorities).
Changes which could result in a cost increase in excess of £1,000 or a change resulting in a substantial delay to the production programme must, in addition, be authorised by the product General Manager.</td></tr>
<tr><td colspan="3"><u>DSS Characteristics</u>
Name of software: None.
Features: Not Applicable.
Functional integration: Not Applicable
Flexibility: Not Applicable
Processing power: Not Applicable</td></tr>
<tr><td colspan="2"><u>User Characteristics</u>
Responsibilities: Senior Management (General Manager, Engineering Manager, Production Manager)
User support:Policy fully document in Departmental Procedure</td><td>User designation:
8</td></tr>
</table>

Figure 13 - A Completed Worksheet 2.1 (Engineering Change Management)

<table>
<tr><td><u>Module:</u> Dispatching Jobs</td><td><u>Family(ies) affected:</u> All</td></tr>
<tr><td colspan="2"><u>Number of transactions:</u> 30 transactions per day (estimated average)</td></tr>
<tr><td colspan="2"><u>Transaction processing policy:</u> Shop floor supervisor will transcribe each production orders based on information from process planning department into shop packet. Each packet represents a job and there may be several packets per production order.</td></tr>
<tr><td colspan="2"><u>TPS:</u>
Software: EFACS
Features: On-line batch processing capability only</td></tr>
<tr><td><u>User characteristics</u>
Responsibilities: Shop floor Department
User support: No formal policy statement.</td><td>User designation
A5,B5</td></tr>
</table>

Figure 14 - A Completed Worksheet 2.2 (Dispatching Jobs)

Module: *Monitoring Shop Floor*	Family(ies) affected: *All*
Number of transactions: *30 transactions per day (estimated)*	
Transaction processing policy: *On completion of each job, shop packets with completion times noted and then returned to the shop floor supervisors who will then logged in the TPS.*	
TPS: Software:*EFACS* Features:.*On-line batch processing capability only.*	
User characteristics Responsibilities:*Shop floor department* User support: *No formal policy statement or formal training programme*	User designation *A5,B5*

Figure 15 - A Completed Worksheet 2.2 (Monitoring shop floor)

Module: *Dispatching Purchase Orders*	Family(ies) affected: *All*
Number of transactions: *30 transaction per requirements plan per day*	
Transaction processing policy: *A requirement plan is transferred to purchasing department in printouts. The purchasing department will then translate the plan into individual purchase orders by keying-in data into the TPS*	
TPS: Software: *EFACS* Features: *On-line processing capability*	
User characteristics Responsibilities: *Purchasing department* User support: *No formal policy statement or training*	User designation *A7,B7*

Figure 16 - A Completed Worksheet 2.2 (Based on Client D)

Module: *Monitoring Purchase Order*	Family(ies) affected: *All*
Number of transactions: *18 per days*	
Transaction processing policy: *Each outstanding purchase order is flagged. An aggregated report of the outstanding orders is produced on a daily basis. The system checks for discrepancies between orders received and orders released.*	
TPS: **Software:** *MAAPICS* **Features:** *Facilities for automatic checks of discrepancies between orders received and order released. Raise outstanding report.*	
User characteristics **Responsibilities:** *Purchasing Department.* **User support:** *No formal policy statement or training programme.*	**User designation:** *A7,B7*

Figure 17 - A Completed Worksheet 2.2 (Based on Client D)

Module: *Dispatching Materials*	Family(ies) affected: *All*
Number of transactions: *15 transactions (i.e. production order) per requirement plan per day (estimated)*	
Transaction processing policy: *A requirement plan is transferred in print-out form to shop floor supervisors. The plan is translated into production orders (i.e. job package) by keying-in details manually into the TPS*	
TPS: **Software:** *EFACS* **Features:** *Batch processing capability only*	
User characteristics **Responsibilities:** *Shop floor department* **User support:** *No formal policy statement or training programme*	**User designation** *A5,B5*

Figure 18 - A Completed Worksheet 2.2 (Dispatching Material)

Module: *Monitoring Stocks*	Family(ies) affected: *All*
Number of transactions: *100 transactions per day*	
Transaction processing policy: *The production operators are expected to indicate the status of his job in a form at the end of each day and then hand it back to his/her supervisor.*	
TPS: **Software:** *EFACS* **Features:** *On-line batch capability.*	
User characteristics **Responsibilities:** *Shop floor department* **User support:** *No formal policy or training programme*	**User designation** *A5,B5*

Figure 19 - A Completed Worksheet 2.2 (Monitoring Stock)

Module: *Request for Engineering Change*	Family(ies) affected: *All*
Number of transactions: *16 per day (estimated average)*	
Transaction processing policy: *Requests for engineering changes are noted in and submitted via form M650 to relevant departments.*	
TPS: Software: *None.* Features: *None.*	
User characteristics Responsibilities: *All (initiators).* User support:	User designation *All*

Figure 20 - A Completed Worksheet 2.2 (Request for Engineering Change)

Module: *Engineering change notification*	Family(ies) affected: *All*
Number of transactions: *(16 per day) Estimated average.*	
Transaction processing policy: *All approvals and rejections are noted via form M650 to relevant departments.*	
TPS: Software: *None* Features: *None*	
User characteristics Responsibilities: *Senior management* User support:	User designation *8*

Figure 21 - A Completed Worksheet 2.2 (Engineering Change Notification)

		User							
Family(ies) affected: *ALL*		*1*	*2*	*A3,B3*	*A4,B4*	*A5,B5*	*6*	*A7,B7*	*8*
Item master	Update interval	Exception	Exception	Exception	Exception	Exception	Exception	Exception	Exception
	Accessibility	On-line	On-line	On-line	On-line	On-line	On-line	On-line	On-line
	Medium	DBMS	DBMS	DBMS	DBMS	DBMS	DBMS	DBMS	DBMS
Work centre	Update interval	Exception	Exception	Exception	Exception	Exception	Exception	Exception	Exception
	Accessibility	On-line	On-line	On-line	On-line	On-line	On-line	On-line	On-line
	Medium	DBMS	DBMS	DBMS	DBMS	DBMS	DBMS	DBMS	DBMS
Statistical	Update interval	As required	As required	As required	As required	As required	As required	As required	As required
	Accessibility	Off-line	Off-line	Off-line	Off-line	Off-line	Off-line	Off-line	Off-line
	Medium	Paper records	Paper records	Paper records	Paper records	Paper records	Paper records	Paper records	Paper records

Figure 22 - A Completed Worksheet 2.3a

		[illegible]							
Family(ies) affected: *All*		*1*	*2*	*A3,B3*	*A4,B4*	*A5,B5*	*6*	*A7,B7*	*8*
[illegible]	[illegible]	Daily	Daily	Daily	Daily	Daily	Daily	Daily	Daily
[illegible]	[illegible]	On-line	On-line	On-line	On-line	On-line	On-line	On-line	On-line
[illegible]	[illegible]	DBMS	DBMS	DBMS	DBMS	DBMS	DBMS	DBMS	DBMS
[illegible]	[illegible]	Daily	Daily	Daily	Daily	Daily	Daily	Daily	Daily
[illegible]	[illegible]	On-line	On-line	On-line	On-line	On-line	On-line	On-line	On-line
[illegible]	[illegible]	DBMS	DBMS	DBMS	DBMS	DBMS	DBMS	DBMS	DBMS
[illegible]	[illegible]	Exception	Exception	Exception	Exception	Exception	Exception	Exception	Exception
[illegible]	[illegible]	Off-line	Off-line	Off-line	Off-line	Off-line	Off-line	Off-line	Off-line
[illegible]	[illegible]	Paper records	Paper records	Paper records	Paper records	Paper records	Paper records	Paper records	Paper records

Figure 23 - A Completed Worksheet 2.3b

		User							
Family(ies) affected: *All*		*1*	*2*	*A3,B3*	*A4,B4*	*A5,B5*	*6*	*A7,B7*	*8*
Inventory status	Update interval	Daily	Daily	Daily	Daily	Daily	Daily	Daily	Daily
	Accessibility	On-line	On-line	On-line	On-line	On-line	On-line	On-line	On-line
	Medium	DBMS	DBMS	DBMS	DBMS	DBMS	DBMS	DBMS	DBMS
Shop floor status	Update interval	Exception	Exception	Exception	Exception	Exception	Exception	Exception	Exception
	Accessibility	Off-line	Off-line	Off-line	Off-line	Off-line	Off-line	Off-line	Off-line
	Medium	Paper records	Paper records	Paper records	Paper records	Paper records	Paper records	Paper records	Paper records
Purchase order status	Update interval	Exception	Exception	Exception	Exception	Exception	Exception	Exception	Exception
	Accessibility	Off-line	Off-line	Off-line	Off-line	Off-line	Off-line	Off-line	Off-line
	Medium	Paper records	Paper records	Paper records	Paper records	Paper records	Paper records	Paper records	Paper records
Engineering Change Status	Update interval	Exception	Exception	Exception	Exception	Exception	Exception	Exception	Exception
	Accessibility	Off-line	Off-line	Off-line	Off-line	Off-line	Off-line	Off-line	Off-line
	Medium	Paper records	Paper records	Paper records	Paper records	Paper records	Paper records	Paper records	Paper records

Figure 24 - A Completed Worksheet 2.3c

STAGE III - Performance Analysis

The competitive position of each strategic chain is a function of two basic dimensions. One dimension correspond to a set of order wining criteria. Order wining criteria are indicators of how well each strategic chain is perceived by its chosen market. The other dimension correspond to criteria of manufacturing liabilities. Manufacturing liabilities are indicators of how well each strategic chain is being managed by the company and, therefore, the sustainability of the chain's competitive position.

The task for the audit team is to establish the achievement of each criteria against appropriate benchmarks.

Completing Worksheet 3.1

Procedure

Step 1. Consider each family in turn.

Step 2. For each of the criteria, where possible, find an appropriate measure. Then compare the measure against appropriate competitive average. The competitive average could be direct comparison with competitors or based on various independent industry reports.

Step 3. Plot the findings on the seven-point scales presented in worksheet 3.1. A zero rating indicates a problematic criterion whereas a seven rating indicate no problem. Note, it may be useful in this case of enagage independent experts to help construct alternative sets of plots and then compare with theirs with yours. Do not accept one set of plots as a *fait accompli.*!

Commentary

The criteria listed in this worksheet are as follows:

(a) **Quality of Design**. Indicate how well the product matches competitions in terms of features.

(b) **Quality of Conformance**. Indicate the extent of customer reject rate, the number of service call outs or the number of warranty replacements.

(c) **Delivery reliability**. Indicate the percentage of total customer orders meeting agreed due date.

(d) **Delivery lead-time**. Compare the time a customer has to wait between the initiation of a customer order and receipt of finished goods with appropriate competitive average.

(e) **Flexibility of Volume**. Indicate the extend of flexibility in delivery lot size.

(f) **Flexibility of Design**. Indicate the extend of customisations afforded.

The audit team is referred to techniques described in a UK Department of Trade and Industry (DTI) publication: "Competitive Manufacturing: A Practical Approach to the Development of a Manufacturing Strategy" (IFS Publications, ISBN 1-95423-010-7)

Completing Worksheet 3.2

Procedure

Same approach as in worksheet 3.1.

Commentary

The criteria for this worksheet are as follows:

(a) Availability of Supplier. Ascertain the level of switching costs that are likely to be incurred in sudden change in supplier.

(b) Reliability of Supplier. Estimate the percentage of bought-out items delivered in the time, quality and volume required.

(c) Utilisation of Bottleneck Resource. Identify bottleneck resource and then obtain indication of their utilisation.

(d) Availability of Non-Bottleneck Resource. Estimate the Mean Time Between Failure (MTBF) for non-bottleneck resource. MTBF is the ratio of average down-time to the cumulative planned working hours.

(e) Inventory Turnover. Calculate the ratio of cost of goods sold to average inventory. Cost of goods sold is defined as the cost of direct materials, direct labour, and overhead attached to the units sold. Average inventory is defined as the sum of beginning and ending inventories divided by two.

(f) Lead time. Calculate the total time it takes to produce a product.

The audit team can use either of the following technique for benchmarking:

(a) Direct comparision.

(b) Industry average.

(c) Independent expert opinions

Worked Example

Scenario. A member of the audit team has complied ratings (see Table 2) as indication of the performance of the CAPM system against the following criteria.

Completed worksheets. Examples of completed worksheets based on the scenario described earlier on are shown illustrated in Figure 25 and Figure 26.

	Product family
Criterion	General Mountain Bicycle
Quality of Design	Not applicable
Quality of Conformance	Not applicable
Delivery Lead-Time	Slightly better than competitor
Delivery Reliability	Slightly better than competitor
Flexibility of volume	Not applicable
Flexibility of Design	Not applicable
Price	Better than competitor
Availability of supplier	Not applicable
Reliability of supplier	Not appliable
Utilisation of Bottleneck Resource	Not appliable
Availability of Bootleneck Resource	Not appliable
Inventory Turnover	Worst than competitor
Lead Time	Slightly better than competitor

Table 2 - View of an Auditor on the Competitive Performance

Family(ies) affected: *General Mountain Bicycles*			
Quality of Design	Worst than benchmark	-3 3	Better than benchmark
Quality of Conformance	Worst than benchmark	-3 3	Better than benchmark
Delivery Lead-time	Worst than benchmark	-3 3	Better than benchmark
Delivery Reliability	Worst than benchmark	-3 3	Better than benchmark
Flexibility of Volume	Worst than benchmark	-3 3	Better than benchmark
Flexibility of Design	Worst than benchmark	-3 3	Better than benchmark
Price	Worst than benchmark	-3 3	Better than benchmark

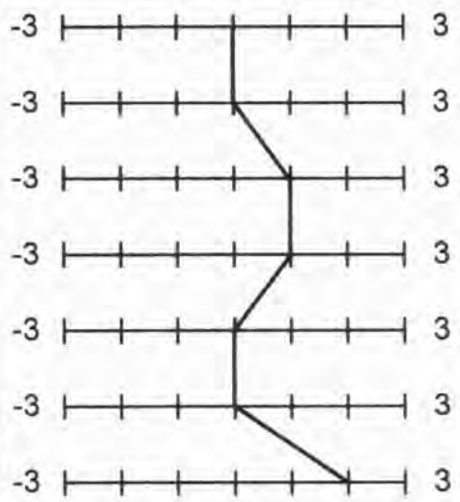


Figure 25 - A Completed Worksheet 3.1

Family(ies) affected: *General Mountain Bicycles*

Availability of Supplier	Worst than benchmark	-3	3	Better than benchmark
Reliability of Supplier	Worst than benchmark	-3	3	Better than benchmark
Utilisation of Bottleneck Resource	Worst than benchmark	-3	3	Better than benchmark
Availability of Non-bottleneck Resource	Worst than benchmark	-3	3	Better than benchmark
Inventory Turnover	Worst than benchmark	-3	3	Better than benchmark
Lead Time	Worst than benchmark	-3	3	Better than benchmark

Figure 26 - A Completed Worksheet 3.2

STAGE IV - Problem Analysis

The task for the audit team is to identify the problems associated with the system they have just audited.

Completing Worksheet

Procedure

Step 1. Get all involved to complete worksheet 4 separately. The procedure to complete the worksheet is as follows:

(a) Consider each family in turn.

(b) Find the most problematic competitive criterion, from worksheet 3.1 and worksheet 3.2, and indicate it on the head of the fish-bone.

(c) Under each branch of the fish-bone identify problematic modules and their key elements (i.e. policies, enabling technology and user).

(d) Repeat the procedure for the all the families involved.

Step 2. Get each member of the team to present and justify their conclusion.

Step 3. Debate the alternative scenarios to find the most plausible.

Commentary

It is left to the discretion of the audit team to establish the links between cause and effect. The only proviso is that the audit team draw and justify their conclusions only from the evidence gathered throughout the audit process. The audit should not introduce threads that are outside the scope of the evidence gathered, unless deemed necessary.

Worked Example

Scenario. A member of the audit team has establish that the following moduless of a CAPM system are the reasons for the poor performance in the criterion "delivery criterion".

(a) Monitoring shop floor.

(b) Master scheduling.

Completed worksheet. Example of a completed worksheet based on the scenario described previously is shown in Figure 27.

Family(ies) Affected: *All*

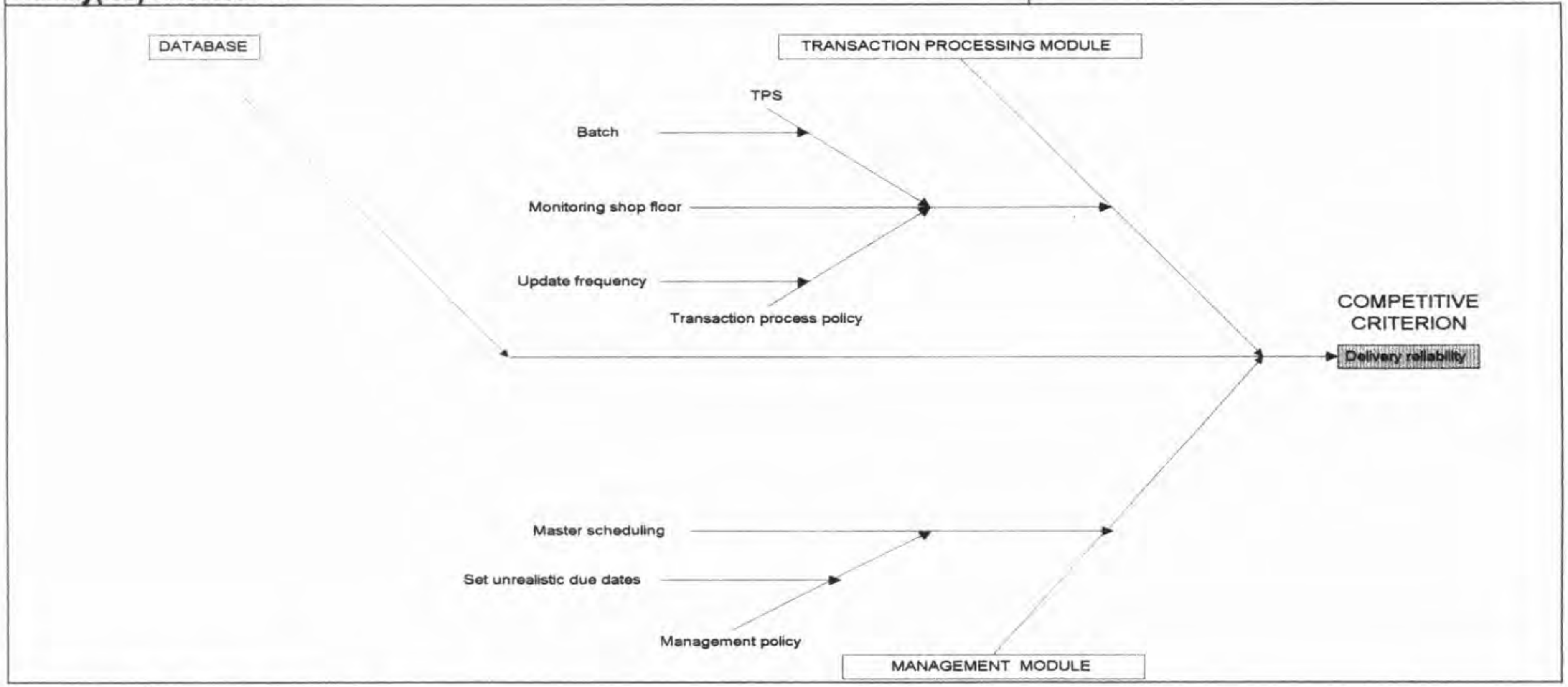


Figure 27 - A Completed Worksheet 4

Worksheets

Worksheet 1.1

Product Family	Sales Revenue (%)	Contribution Margin (%)	Growth Potential	Market Share	Competitors

Worksheet 1.2

Product Family	Product Position	Product structure	Number of components	Bought-out items (%)

Worksheet 1.3

		Manufacturing capability			
Product Family	Business unit	Design?	Assembly?	Machining?	Inspection?

Worksheet 2.1

<u>Module:</u>	**<u>Family(ies) affected:</u>**
<u>Management Policy</u>	
<u>DSS Characteristics</u> **Name of software:** **Features:** **Functional integration:** **Flexibility:** **Processing power:**	
<u>User Characteristics</u> **Responsibilities:** **User support:**	**User designation:**

Worksheet 2.2

Module:	Family(ies) affected:
Number of transactions:	
Transaction processing policy:	
TPS **Software:** **Features:**	
User characteristics **Responsibilities:** **User support:**	**User designation**

Worksheet 2.3a

		User
Family(ies) affected		
Item Master	Update interval	
	Accessibility	
	Medium	
Work centre	Update interval	
	Accessibility	
	Medium	
Statistical	Update interval	
	Accessibility	
	Medium	

Worksheet 2.3b

		User
Family(ies) affected		
Master schedules	Update interval	
	Accessibility	
	Medium	
Requirements plans	Update interval	
	Accessibility	
	Medium	
Process plans	Update interval	
	Accessibility	
	Medium	

Worksheet 2.3c

		User
Family(ies) affected		
Inventory Status	Update interval	
	Accessibility	
	Medium	
Shop Floor Status	Update interval	
	Accessibility	
	Medium	
Purchase Order Status	Update interval	
	Accessibility	
	Medium	
Engineering Change Status	Update interval	
	Accessibility	
	Medium	

Worksheet 3.1

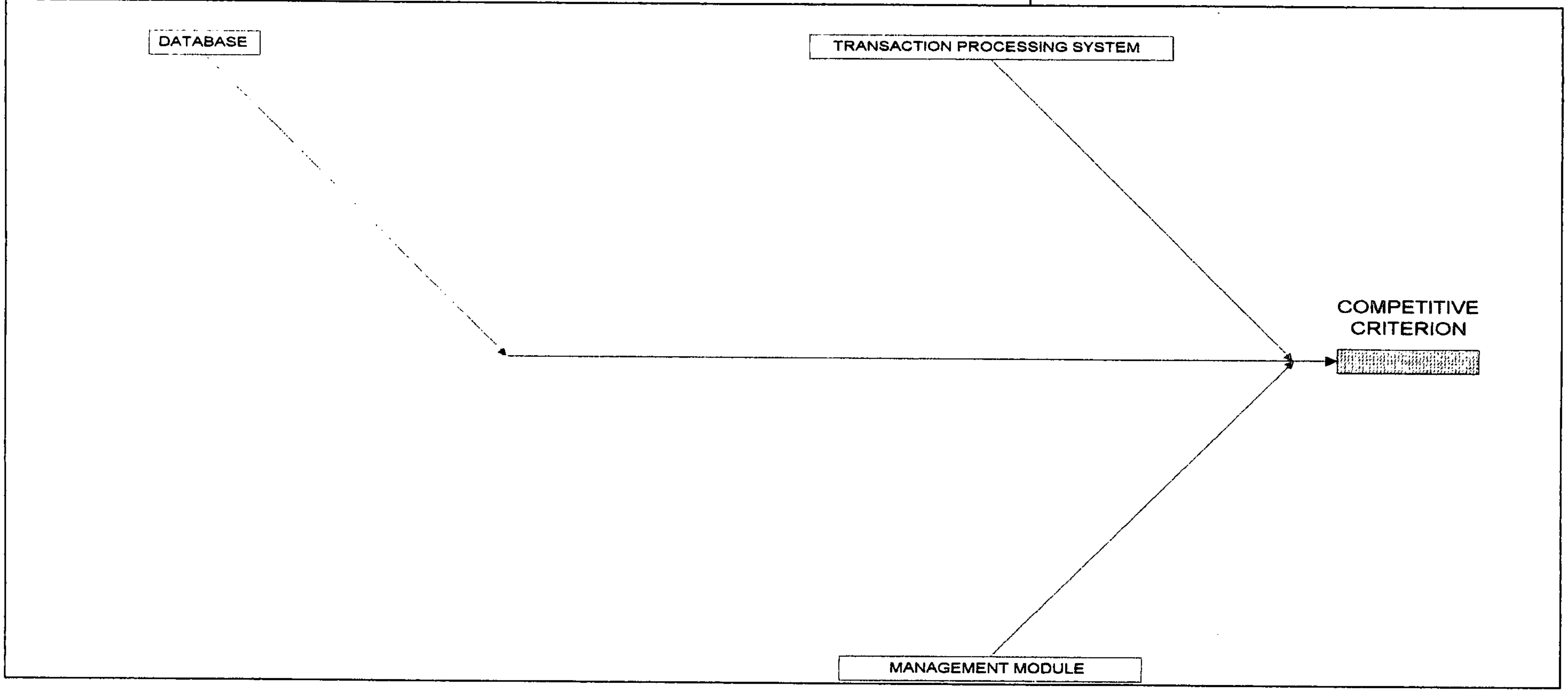
Family(ies) affected:				
Quality of Design	Worst than benchmark	-3	3	Better than benchmark
Quality of Conformance	Worst than benchmark	-3	3	Better than benchmark
Delivery Lead-time	Worst than benchmark	-3	3	Better than benchmark
Delivery Reliability	Worst than benchmark	-3	3	Better than benchmark
Flexibility of Volume	Worst than benchmark	-3	3	Better than benchmark
Flexibility of Design	Worst than benchmark	-3	3	Better than benchmark
Price	Worst than benchmark	-3	3	Better than benchmark

Family(ies) affected:

Availability of Supplier	Worst than benchmark	-3 ├─┼─┼─┼─┼─┼─┤ 3	Better than benchmark
Reliability of Supplier	Worst than benchmark	-3 ├─┼─┼─┼─┼─┼─┤ 3	Better than benchmark
Utilisation of Bottleneck Resource	Worst than benchmark	-3 ├─┼─┼─┼─┼─┼─┤ 3	Better than benchmark
Availability of Non-bottleneck Resource	Worst than benchmark	-3 ├─┼─┼─┼─┼─┼─┤ 3	Better than benchmark
Inventory Turnover	Worst than benchmark	-3 ├─┼─┼─┼─┼─┼─┤ 3	Better than benchmark
Lead Time	Worst than benchmark	-3 ├─┼─┼─┼─┼─┼─┤ 3	Better than benchmark

Worksheet 4.1

Family(ies) Affected:



Appendix A

The EFACS Package

EFACS is a comprehensive, user-friendly manufacturing control system. It is designed to operate in many branches of manufacturing industry, and is easily and quickly assimilated into the normal workings of the company, yielding significant improvements in efficiency, performance and profitability. EFACS is a modern, portable and flexible system using the latest in software techniques. It will run on a wide range of microcomputers, mini-computers and mainframes under the Unix operating system.

EFACS is designed to satisfy the large majority of the requirements of a manufacturing company. Any special requirements are bespoked, resulting in avoidance of unnecessary complexity, and in a system which becomes much more readily integrated into the company's operations. EFACS is modular and software can be selected from the following range: Parts Master, Bill of Materials, Routing, Resources, Work in Progress, Shop Documentation, Capacity Planning, Scheduling, Extended Scheduling, Costing, M.R.P., Quotations, Sales Order Processing, Purchase Order Processing, Stock Control, Material Traceability, Shop Data Collection, Time & Attendance, Tetraplan Links and Management Reporting.

EFACS is written in the 'C' language which gives it portability, so that software investment is protected, avoiding the problem of being "locked-in" to a particular hardware manufacturer. It also links with the Informix-SQL data base management system and other utility software such as Unipex and Lynx.

Menu System

EFACS has a user-friendly, easy to operate menu system designed to suit the needs of a wide variety of users, and with a number of unique, practical features.

- Selection of a menu-option by cursor-keys, space bar or keying in a number will either obtain a new menu, a report or start a process.
- A user-configurable "quick menu" system enables options from all parts of the EFACS system to be brought together onto the one screen. This can be useful in certain applications which require movement between a number of menus.
- The view a particular user has of the EFACS system is also configurable. An individual user will see only those menu options applicable to him. This can be especially useful in implementation periods, to avoid presentation of too many options.
- A particular menu option may be executed from any point by keying in its reference number.

Record Selection

EFACS has powerful in-built query facilities which enable selection of a record or group by entering suitable search criteria onto a screen. For instance, the user may wish to select parts where the product group was "BAR" and length was between 0.95 and 1.05 metres. This is simply accomplished by entering this information onto the Parts Master data entry screen and pressing a key. The computer will then select the records concerned and allow the user to move from one record to the other.

EFACS also has a query facility in certain programs which will display alternative records in a window on the screen, enabling the user to select from the options given, whereupon the window disappears leaving the selected information. This facility is useful for instance in tele-sales entry where rapid detection of a customer is important.

SQL

EFACS has a full "Structured Query Language" facility which allows the user to report and to modify data in the EFACS database, and to perform a wide range of system functions. Some of its facilities are:

- Output information direct to a screen or printer with a command such as:

  Select won, wpart, woq, wduedate, wcustomer from works orders where wcustomer = "SMITH" order by wduedate

- Modify data on the database with a command such as:

  *Update partmaster set unitprice = unitprice * 1.06 where prodgroup = "BAR" and uom = "M" and unitprice > 0.500*

  This will perform a price increase for selected parts.
- A comprehensive facility for data security with commands such as:

  Revoke update on partmaster from public;
  Grant update on partmaster to manager, joe

  This ensures that only users "manager" and "joe" are allowed to change any data on the Parts Master file. More complex constructions are also allowed.
- A full audit trail facility may be applied to any file in the EFACS database. A full transaction processing facility is also available.

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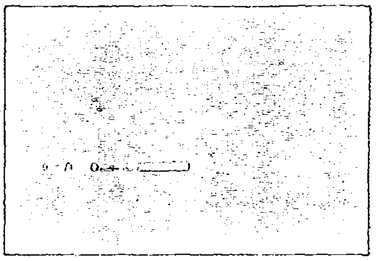
Informix

EFACS has an interface to the powerful and well-known Informix-SQL database Management System. This has a sophisticated range of report writers, screen generators and utilities which will appeal to many EFACS users. Also available is Informix Turbo which will improve operational performance to even higher levels than the very high level of the standard system.



System Management

EFACS has a menu-driven system management facility which controls printer status, software updates, system and data back-ups, database index repair, current users and processes, formatting of disks, archiving of data and so on. The organization of all common utility functions into the system management menu very much improves the ease of performing these vital functions.

Help Functions

On-screen help facilities are available at a number of levels. Depressing the 'H' key at menu level brings up a help message about the particular menu option. Secondly, the EFACS User Guide may be accessed through its own menu and be paged through on-screen. Thirdly, help facilities using window displays are available at selected points in the applications software. In total, EFACS has a comprehensive on-screen help facility designed to assist the user into a full and competent understanding of the system.

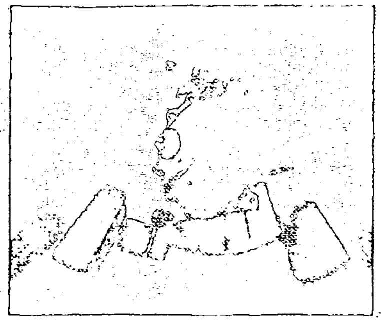
EFACS MODULES

PARTS MASTER

The Parts Master module provides a common, centralized source for vital manufacturing information, and is used by all other EFACS modules. A 'part' may be a purchased item, raw material, component, sub-assembly, assembly or finished part.

In many organisations paperwork moves slowly, picking up errors as it goes. This inevitably leads to management having to make decisions on poor information, which can lead to late deliveries, customer dissatisfaction and loss of competitiveness. These problems can be reduced by having a single source of information readily available.

* EFACS uses a 14-character alpha-numeric part number
* Product group classification, enabling accessing of parts information by product.



* Unit of measure, eg, Kg, Metres, Each, Litres, Boxes, Square Metres etc
* Customer code and customer part number may be entered where the part has a single customer
* Normal quantity in which the part is manufactured
* Dimensional information such as length, width, height, diameter, packing factor, weight, etc
* Material specification and size.
* Whether the part is manufactured or purchased
* Casting reference number
* Current and standard material, overhead, and unit costs
* Selling price per unit
* Controller reference
* A free text facility enables a block of text to be held on file against the part number, and to be output if required on Shop Documentation, Purchase Orders etc. EFACS free text may be manipulated with the system editor, EFACS word processor software or with a specialist word processing package.
* Bespoke modifications to the Parts Master module, especially to hold information particularly relevant to the user company, are also available.
* EFACS has a powerful search facility to locate a particular part record based on for example dimensional ranges, and short-form part numbers and descriptions.
* Display parts information to screen and to printer in various formats.

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BILL OF MATERIALS

The Bill of Materials module is designed to handle parts and assemblies composed of sub-assemblies, components, purchased items and raw materials. These items can be linked together into a structure showing the quantity of each item required at each level. In a typical bill of materials structure, a varying range and quantity of child parts are required to be available before manufacture of a parent part can begin. Once this information is entered into the system, then reference to the assembly part number will enable immediate reference to be made whenever needed to all sub-assemblies, components and materials required for the assembly.

- Parent and child parts are checked against the Parts Master file.
- Descriptions for both parent and child parts are displayed automatically at data entry time.
- Numbers of components per parent part are floating point numbers
- Up to 30 levels
- Indented bill of materials details report.
- "Used-on" reports to screen and printer.
- Automatic generation of a series of manufacturing or works orders
- Copy and edit, or delete, whole structures.
- Replacement of one part by another through all structures or selectively.
- Changing materials costs and planned manufacturing times are reflected to higher levels through a cost build-up procedure, based either on standard or current costs.
- Phantom assemblies may be created which require no stock or routing information.
- Allocation and issuing of kits of parts, together with monitoring of kit shortages
- Printing of picking lists.

ROUTING

The Routing module handles detailed information about the series of operations required to make a manufactured item. When combined with the Parts Master module, and also the Bill of Materials module if structures of parts are used, the Routing module provides information for the Work in Progress, Capacity Planning, Scheduling, Extended Scheduling, MRP and Quotations features of the system.

The Routing module assembles detailed information on machine, skills planned times, etc., on the Routing File. Detailed manufacturing instructions and tooling requirements for each operation are held on associated files.

- Part number verified by the system to ensure that it exists on the Parts Master File.
- Operation number automatically increases to facilitate data entry.
- On entry of the planned machine or work centre, the system automatically displays the machine description
- Set-up time for the batch in minutes
- The run-time can be for a certain number of items (eg. per 1 or 10 or 100) or for the whole batch regardless of quantity, as in a heat treatment or inspection operation. Run-times may also be entered as quantity per minute or per hour
- An overlap percentage can be used to allow an operation to begin before the previous operation has been completed.
- Drawing reference.
- Allowance for transfer time from the end of one operation to the start of the next operation.
- Facility for specification of required skill level on the planned machine for the current operation.
- 40-character short description of the operation.
- A list of tools can be held against each operation.
- An unlimited number of lines of manufacturing instructions can be held against each operation and later printed on operation or routing cards. The instructions free text may be manipulated by internal or external word processing software
- Alternative operations or alternative routes are allowed with a complete independent set of manufacturing information for each alternative. Each alternative operation may be assigned a preference value, which is considered by Capacity Planning.
- Planned sub-contract work can be specified for an operation with a fixed and/or unit cost.
- A percentage quantity loss is allowed against an operation
- Allowance is made for the number of operators required on an operation.
- Reduced amount of data entry by copying an existing part with all manufacturing information to a new part for subsequent amendment
- Summary and detailed reports on demand to both screens and printers

RESOURCES

Before the Capacity Planning and Scheduling modules of EFACS can be applied, the computer must have knowledge of both factory load and capacity. The Resources module enables detailed information to be kept on file about the various factors which affect capacity. Thus, files are available to hold details of shift and holiday patterns, machines, operators, sections, tools, jigs and fixtures. One of the characteristics of EFACS is the level of detail in which it considers items relating to factory capacity. For example, complex shift and holiday patterns may be specified, with additional facilities for recording short term machine and operator

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blocking. The user also has the ability to specify which machines an operator group may be assigned to with preference and skill levels against each.

* Definition of complex shift patterns.
* Definition of holidays.
* Sections identification, ie. group of machines.
* 8-character identification for machine groups and operator groups.
* Machine group and operator group performance factors.
* Machine and operator hourly rates (£/hour), for production costing and for sales.
* Shift and holiday definitions determine machine and operator capacity.
* Machine non-availability due to planned or unplanned maintenance or breakdown.
* Operator classifications as setters, operators or setter/operators.
* Operator machine list with preference level, combination performance factor and skill level.
* Operator non-availability from a date/time to a date/time.

* 8-character tool identification.
* Tool classification into jig, tool, fixture, etc.
* Tool location.
* Tool availability.

WORK IN PROGRESS AND SHOP DOCUMENTATION

The Work in Progress module keeps track of work on the shop floor as it passes through its various manufacturing stages. It has two main files, the Works Orders File and the Work in Progress File.

The Works Orders File contains details of each works order, when it is due, the order quantity, customer and so on.

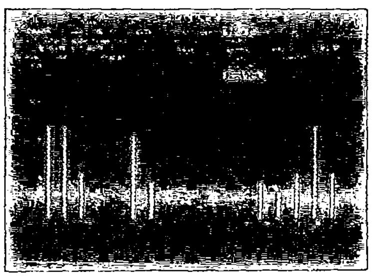
The Work in Progress File has records for each job-operation, and enables detailed planning and monitoring of the progress of each job. Actual times and costs can be accrued for later processing, and the exact status of any job can be ascertained at any time.

The Work in Progress module may be linked with the Data Collection module to assist in data entry.

* Works Order File referenced by unique works order number.
* Category, eg. not started, in progress or complete.
* Part description is displayed automatically.
* Parent works order is held if applicable.
* Order quantity.
* Due date for the order to be completed. This may be varied subsequently.
* Works order 'don't start till' date to prevent work being scheduled too early.
* Customer code and customer order number.
* A manually set order priority number.
* Sales order reference, in the case where a works order is raised directly from a sales order.
* 40-character comment line.
* Free text may be held against the works order to be output onto shop documentation or to be used as a note-pad.
* Work in Progress File is referenced by works order number and operation number.
* Operation state, eg. not started, setting, set complete, running or complete.
* Quantity ordered, quantity left, quantity scrapped.
* A 'don't start till' date for the operation.
* Operation latest start date is calculated from the works order due date by a back-scheduling process.
* All routing information, eg. operation number, machine, set and run times, etc. are fetched automatically at works order entry time from the Routing File.
* Routing information may subsequently be amended for a particular works order without affecting reference data on the Routing File.
* Ability to fetch the latest routing information from the Routing File for operations which are not yet started.
* Facility to make any number of bookings of machine and operator time against an operation.
* Recording of bookings may be manually made directly or through a time-sheet procedure, or alternatively may be collected automatically through Shop Floor Data Collection.
* Detailed and summary reports to screen and printer.
* Shop documentation as route card or separate operation cards, complete with tooling requirements and detailed manufacturing instructions.
* Shop documentation optionally prepared with incorporated bar code on each operation card, and printed on standard printers.
* Reports to screen and printer of work in progress valuation and remaining work.
* Summary status of works orders by customer.
* Batch-splitting facility enables a works order to be divided whilst still allowing full material traceability.

CAPACITY PLANNING

The Capacity Planning module tackles one of the fundamental problems facing manufacturing industry, that of how to plan and control the complexities of manufacturing many jobs, each composed of a series of operations, and using limited resources. Three separate procedures are available: finite capacity planning, infinite capacity planning and delivery date estimation. Finite capacity planning produces an accurate, feasible and



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efficient manufacturing plan, infinite capacity planning is useful for determining bottlenecks, and delivery date estimation provides a quick means of arriving at realistic delivery dates for new orders.

Finite capacity planning takes into account the current shop floor situation, availability of machines and operators, required skill level, operator preferences, performance factors, overlapping, job priority, alternative machines, etc. Setting and running are treated as separate sub-operations

The main outputs of finite capacity planning are comparisons of load and capacity data, and projected completion dates. The load/capacity data will indicate any under or over-utilized resources, or where the mix of setters, operators, machines and skills require modification. The projected completion dates will show when orders will realistically be completed. This information may differ unacceptably from the due dates of the orders. Changes can then be made to due dates, priorities and capacity on a 'what-if' basis until an acceptable plan emerges. Decisions may be made to sub-contract, work overtime, or re-train based on this report. The emphasis in finite capacity planning is enabling accurate, quantitative decision making based on a proper analysis of load and capacity.

The infinite capacity planning procedure aggregates loads onto works centres based on works order due date and manufacturing times. Future over-load situations may therefore be predicted.

Delivery date estimation requires input of a potential new order as a part number and quantity. This order is run against the last finite capacity run at two levels to give a best possible and realistic delivery date.

A special report is available to indicate when capacity shortages of machines, setters, or operators are likely to cause production bottlenecks.

- Selects today as start date by default.
- Capacity planning horizon may be set up to 1000 days.
- Optionally ignore operator capacity.
- Optionally ignore skills.
- Set a constant transportation time between operations.
- Histograms to screen or printer compare capacity with load to show machine and operator forward loading, with indication of bottlenecks and under-utilization.
- Coloured histograms showing finite and infinite loadings side-by-side against available capacity.
- Histogram displays scroll forwards and backwards in time.
- Histogram time units chosen by drop-down menu.
- Screen or printer reports of projected order status, where due dates are compared with achievable dates, thus highlighting delivery problems at an early stage and enabling corrective action to be taken

- Ability to operate in 'what-if' mode so that the effect on the overall position of changing order priorities, over-time, sub-contracting, rush orders, etc. can be accurately evaluated
- Finite capacity planning may be run iteratively with MRP to provide full MRPII facilities

SCHEDULING

Scheduling is a by-product of the finite capacity planning process, where detailed allocations of machine and operator capacity are made to job operations. The schedules produce better and more realistic manufacturing plans than are available from most alternative computer systems. Using these schedules ensures that jobs are progressed in proper priority and use available capacity in an efficient way. If more elaborate schedules are required then these are available in the Extended Scheduling module

- Schedules may be produced for as many days forward as required.
- Schedules to either screen or printer
- Schedules can be produced by job, by machine group, by operator group, or by section.
- Schedules can be produced on demand for particular works orders, machine groups or operator groups.
- The schedules can be produced as often as required and will reflect the latest work in progress and capacity situation

- Setting and running are treated as separate sub-operations
- A tool schedule may be produced showing the forward requirement for tools, in-line with the feasible manufacturing plan produced.

EXTENDED SCHEDULING

The Extended Scheduling module provides precise schedules taking into account a range of factors such as job lateness, job priority, skills, preferences, machine and operator utilization and work in progress levels

EFACS Extended Scheduling is a precise technique which takes into account the important factors involved in establishing an efficient and optimal manufacturing plan. Having such a plan enables the company to improve delivery performance, increase resource utilization, reduce throughput times and work in progress levels, as well as introducing a higher level of management control.

- Reconciles conflicting objectives such as considering job priorities, limiting idle time, reducing job lateness, avoiding over-skilling, and ensuring that operator/machine preferences are met where possible.

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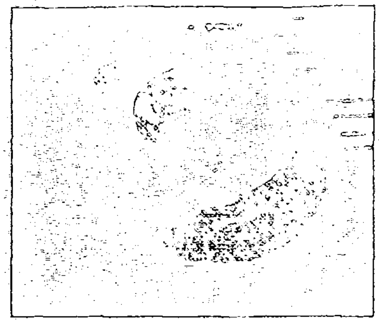

- Uses a special dynamic-logic technique, which enables varying importance to be given to each of those objectives.
- Different schedules can be produced, enabling the user to produce a manufacturing plan which gives emphasis to the factors of particular current importance.
- Provides detailed, short-term, manufacturing plans of an accuracy and quality which alternative computer systems rarely claim to achieve.
- Scheduler can be run for as long a time period as required.
- Gantt charts to both screen and printer available for works orders, machines and operators.
- User special scheduling requirements are often possible through relatively straightforward modification of the scheduling method.

MATERIAL REQUIREMENTS PLANNING

The Material Requirements Planning (MRP) module provides a full breakdown of requirements for component parts and materials for sixteen days, weeks, or months ahead, using the fully-regenerative method. Factors taken into account in producing the requirements plan are sales orders, purchase orders, work in progress, works orders, bill of materials and existing stock levels. MRP is invaluable where assemblies or structures of parts are involved, and parts are wholly or partly held in stock.

Application of MRP will ensure that component parts and materials are available in the correct quantities at the correct times to satisfy the main manufacturing plan.

- Works Orders, Master Schedule, Sales Orders and Work in Progress Files are broken down by the bill of materials to determine gross requirements.
- Gross requirements are compared with outstanding purchase orders and current stocks before ascertaining the potential future shortage position.
- Replenishment orders are recommended.
- Alternative batching rules are available in determining recommended orders:
  1) Multiple of re-order quantity.
  2) Re-order quantity plus rounding.
  3) Minimum quantity.
  4) Quantity required.
- Works orders may be broken down either by their due dates, or by their estimated completion dates as given by finite capacity planning, and will have a corresponding effect on the timing of material and component procurement.
- Delivery lead times on manufactured items may be calculated from operation times on the Routing File and take batch size into account, or may be read directly from the Stock File.
- Requirements reports to screen and printer showing current stock levels, gross requirements, items on order, and nett requirements.
- Recommended order report with critically late orders highlighted.
- Recommended orders for purchased items may optionally be applied automatically to the Purchase Orders File.
- Recommended orders for manufactured items may optionally be applied automatically to the Works Orders File.
- Master schedule items may be applied temporarily to the Works Order File to enable finite capacity planning to include these items.
- Ensure that components, sub-assemblies and raw materials, whether manufactured or purchased, are provided in the right quantities at the right times to meet the high-level manufacturing programme.

COSTING

The EFACS Costing module includes two types of costing, cost estimation and job/variance costing. The cost estimation routine allows an enquiry to be processed quickly and an accurate quote given. Job/variance costing enables recording of actual costs and times and compares with planned costs and times. If combined with the Data Collection module, feedback from the shop floor of actual costs can be virtually instantaneous providing constantly up-to-date costings.

- Cost estimation report showing labour, material, and overhead costs, and item and job costs based on up-to-date information on Parts Master and Routing Files.
- Times taken may be calculated directly from start and finish date/times, taking due allowance for shift changes, holidays, and machine and operator blocking.
- Summary and detailed reports to screen or printer compare planned times and costs with actual times and costs, and provide performance measurements.
- Works order, operator and machine costing showing actual against estimated costs.
- The detailed works order costing report shows labour, sub-contract, and material costs, both planned and actual, together with miscellaneous expenses to give a complete cost breakdown for the works order.
- Enables strict cost control through presentation of information in suitable formats.
- Setting time and running times are recorded separately.
- Links directly with other EFACS modules.

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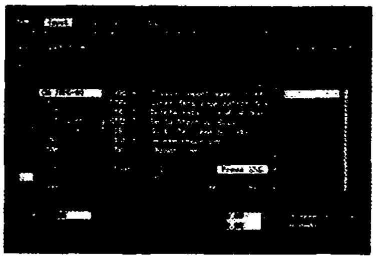
QUOTATIONS

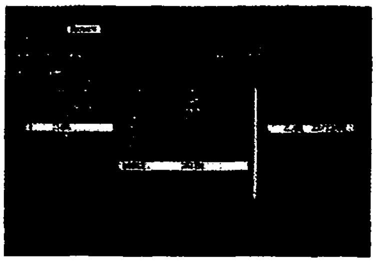
The Quotations module is designed to enable efficient generation of quotations, together with monitoring of existing quotations and transfer of information to Sales Orders, Works Orders, Routing and Parts Master Files upon acceptance. Several alternative ways of arriving at a price are provided

- Using windows, search for an existing customer and for an existing part number
- Enter details of a new customer including name, contact, title, telephone number, address and delivery, directly against the quotation
- Enter new parts and routing information against the quotation
- Call up and modify existing routing information
- Cost estimates for the job and for each operation are shown on-screen as the route is developed
- Allow for sub-contract costs
- Operation costs based on planned times and work-centre selling rates.
- On-screen display of previous works orders for the part concerned, with actual manufacturing costs shown against planned costs
- On-screen display of previous sales orders for the part concerned, with customers, quantities, dates and prices
- Arrive at a price by applying a customer/part number/quantity discount on the basic unit selling price.
- Hold free text against the quotation at two different levels, firstly to output directly onto the customer quotation and secondly to serve as a record of progressing activity.
- Output the quotation onto a printer or send directly to your customer from the computer by fax.
- On acceptance, transfer new customer, address, part number and routing information onto the main system
- Display and print quotation reports by part number, customer and status
- Monitor success rates
- Ensure that quotation management and control is performed in an orderly, efficient manner.



SALES ORDER PROCESSING

EFACS Sales Order Processing generates and maintains sales orders and interfaces with Quotations, Work in Progress, Stock Control, Purchase Order Processing, Material Requirements Planning and Sales Ledger. The system gives the user the option to satisfy an order from existing stock, to create a new works order or to create a purchase order. Sales orders can either be despatched as a complete order, or as individual items. Invoices and despatch notes can be produced automatically or manually, and can be tailored to individual requirements



- Sales order number automatically increments.
- Sales order is multi-item.
- Specified invoice and delivery address numbers.
- A trial kitting procedure is available to determine whether sufficient component stocks exist to make an assembly.
- Fast 'tele-sales' entry procedure searches for customer and part number using windows, checks customer credit balance, and makes stock enquiries before checking the sales order item
- Facility for scheduled sales orders and blanket sales orders.
- Adjustment of existing sales orders.
- Price Break File holds discount for a part number and customer at a given quantity level
- Order acknowledgement can be printed or sent directly to customer as electronic mail
- Works orders can be raised automatically from a sales order item
- Comparison of outstanding sales order items and finished goods stock with recommendations for despatch.
- Allows for both under and over-deliveries
- A particular despatch may include items from various sales orders for the customer concerned
- Four lines of invoice narrative and four lines of despatch note narrative are allowed
- Batch printing of invoices and despatch notes, with optional extra prints.
- Sales order despatch procedure updates sales order, delivery file, transaction file, stock file, prepares invoices and despatch notes, and posts to sales ledger.
- Display and print sales orders by sales order number, part number, customer and due date

PURCHASE ORDER PROCESSING

The Purchase Order Processing module enables control to be effected over the important task of providing component parts and materials required to meet the main manufacturing programme. Automatic procedures exist for placement, despatch and receipt of purchase orders, making the system efficient in operation.

- Purchase order number automatically increments.
- Purchase order is multi-item.
- Supplier name and address displayed automatically
- 4 lines of purchase order narrative.
- 3 lines of purchase order item narrative
- Unlimited free text against the purchase order item
- Entry of scheduled purchase orders and blanket purchase orders
- Under, over and part receipts.
- Returns to supplier
- Purchase order receipt normally automatically updates stock records

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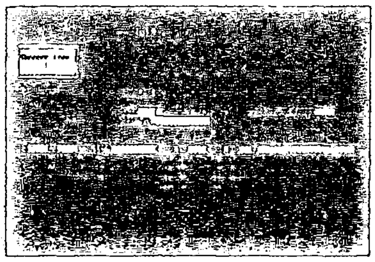
- Special facility for dealing with sub-contract work.
- Multi-currency.
- Automatic GRN generation.
- Delivery address is variable.
- Unit-of-measure is variable.
- Display and print purchase orders by part, supplier and due date.
- Forward purchasing commitment.
- Automatic placement of MRP recommended purchase orders.



STOCK CONTROL

The Stock Control module enables accurate stock records to be kept on the computer, and is a considerable improvement on manual methods which involve keeping a large amount of data on stock cards.

Accurate and timely information about stock levels is an important factor in ensuring company efficiency and profitability. The Stock Control module contains up-to-date information on existing stock levels, allocated stock, outstanding orders, lead times, usage and so on.

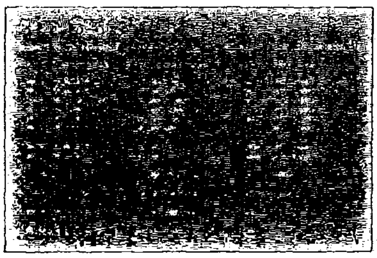
Detailed reports are provided on stock levels and value, re-ordering information, and a complete transaction history. As a consequence re-ordering is closely allied to stock demand, potential shortage situations are reduced, over-stocking is avoided, and in general the two conflicting objectives of good service and minimal inventory are reconciled.

- Stock number is checked against Parts Master File.
- Physical stock, quantity on order, free stock, allocated stock and minimum stock permissible.
- Re-order point, re-order quantity, rounding quantity and re-order policy, eg. whether MRP or re-order point control.
- Lead time for purchased and manufactured items.
- Usage per week.
- Automatic procedures for stock issues, receipts, and adjustments.
- Full audit trail on all transactions.
- Reports to screen and printer of stock status, stock valuation, and transaction history.
- Recommended stock orders for re-order point controlled items.
- Comprehensive stock-take facility allowing perpetual inventory control, annual stock-take, ticket numbering facility, and comparison of stock count with computer physical stock before confirmation.
- ABC analysis.

MATERIAL TRACEABILITY

The EFACS Material Traceability module enables full account to be taken of movement of batches of stock to meet the requirements of British Standard BS5750. A detailed transaction history is kept which allows for the identification of, for instance, all finished good items affected by a specific material batch. A number of EFACS modules are integrated including Work in Progress, Stock Control, Purchase Order Processing, Sales Order Processing, Bill of Materials and Shop Documentation.

- Multi-item stock record with unique serial batch number.
- Works order completion generates a new batch number for subsequent quality approval.
- Purchase order receipt generates a new batch number with quality initially not approved.
- A quality assurance procedure confirms physical stock availability.
- Stock-take facility applies to batches.
- Production of Certificate of Conformity.
- Production of rejection notes.
- Display and print a trace of usages through a number of levels, both backwards from a finished item and forward from a material or component item.



DATA COLLECTION

The EFACS Shop Data Collection module enables fast, accurate updating of the Work in Progress and Costing modules. Bar codes can be printed using standard system software, on a standard printer, so that works order number, operation numbers, operators, machines, quantities, and so on can all be entered via bar code readers.

The Data Collection module is fully integrated with the rest of the EFACS system so that the Work in Progress and Costing modules are updated automatically.

- Uses an industry-standard data collection terminal.
- Up to 255 terminals can be connected on a network and accessed from one computer port.
- The data collection hardware serves for work in progress monitoring, time and attendance, stock control and bespoked enhancements.
- Rugged easy-to-use bar code terminals with sealed numeric or alpha-numeric keypad.
- Reduce the time-consuming data entry of conventional labour booking systems.
- Terminal can store 24000 characters in battery backed memory.
- Real time data collection with on-line validation.
- Shop Floor terminals programmable to allow tailored terminal response.
- Bar-coded job tickets, clock cards, etc. are produced by the system.
- Collected data is date and time-stamped automatically.
- Bar codes printed using standard software and IBM/Epson compatible printers.
- Facilities for entering works order numbers, operation numbers, machines, operators, quantities, etc.

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- Record issue of a job and its completion, and allow system to calculate time difference allowing for shifts, holidays, attendance, etc.
- Exception reporting where entered times taken are different from calculated time differences.
- Computer continually scans for bar-code data receipt.
- Work in Progress and Bookings Files are automatically updated.
- Report errors and warnings to error log for subsequent display or printing.

TIME AND ATTENDANCE

The EFACS Time and Attendance module monitors attendance with the use of bar-coded collection terminals, and produces a variety of reports with an optional link to a payroll facility.

- Bar-coded clock cards can be generated using a standard printer
- Industrial quality data collection terminals are used to collect clocking on and off information
- Paid and unpaid breaks are handled.
- Flexible tolerance banding around planned start and finish times.
- Link to payroll system with standard rate plus three over-time rates.
- Who's in/Who' out reports available to both screen and printer
- Exception reporting.
- Manufacturing hours calculated from attendance and work-in-progress monitoring.

MANAGEMENT REPORTING

EFACS has a comprehensive management reporting function which draws information from all parts of the EFACS system for collation, analysis and presentation as summary reports for management purposes.

- Presentation of data on quotations, sales orders, purchase orders, work in progress valuation, labour hours worked, machine down-time, stock, scrap, despatches, etc
- Entry of budgets with facilities to spread them across varying time periods.
- Variances against budget.
- User definition of report formats
- Bespoke enhancement to produce detailed reports to specific user formats.